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WASTED FORCES.*

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THOSE inventions are deserving of special honor, and generally receive the most substantial recognition, which develop new industries or utilize waste products.

The glycerine industry, which has attained colossal proportions, is a notable illustration of a great manufacture based entirely upon the saving of what until lately was a waste product of the soap-boiler. As even more important, I may mention the industries connected with the manufacture of aniline dyes and artificial madder from the refuse coal-tar that was formerly the curse and nuisance of the gas-works. Old boots and shoes and leather waste are turned to good account by the chemical manufacturer in producing the cyanides, ferro and ferrid cyanides, so indispensable in color-printing and photography. Of the carcasses of slaughtered animals, not a scrap or morsel is allowed to go to waste, as you are well aware; and even the waste blood of the abattoir is used by the sugar-refiner and the manufacturer of albumen. Sawdust mixed with blood, or some other agglutinative substance, and compressed by powerful pressure in heated dies, is formed into door-knobs, hardware and furniture trimmings, buttons, and a thousand useful and decorative articles; or, as is the case with the spent bark of the tanneries, it is utilized for fuel under steam-boilers. Oyster-shells, of which our barbarous progenitors of ages ago made the shell-mounds that delight the soul of the anthropologist of to-day, are burned to lime; the waste of the linseed-oil manufacturers is eagerly sought after as food for cattle; the waste ashes of wood-fires are leached for potash; river-mud is mingled with chalk, and burned and ground to

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make the famous Portland cement; and the ruthless hand of Utilitarianism has not even respected the brickbat, that had served from time immemorial only to crack the heads of opposing factions, but grinds it up to make cement with lime. The finest glue size is made from the waste of parchment skins. The waste gases of the blast-furnace are now utilized to heat the blast, to generate the steam that drives the engine that makes the blast, to hoist ores, drive machinery, etc.; and even the slag, that has served for years only to decorate the hillsides, is now cast into paving and building blocks, or granulated to make building sand, or ground for cement, or mixed with suitable chemicals and turned into the commoner grades of glass, or blown by a jet of steam into the finest filaments to form the curious substance called mineral wool, now largely used as a non-conductor of heat upon steam-pipes, boilers, roofs, etc., etc.

So, too, the enormous hills of anthracite-coal dirt, that in the coal regions of our State have for years borne silent but eloquent testimony to the crudity and wastefulness of our methods of mining coal, now bid fair soon to disappear beneath boilers supplied with ingenious dust-burning devices, or in the form of lumps of artificial fuel. Even the anthracite-coal deposits, now so enormously valuable, were a few years ago but so many layers of black stone, unappreciated and valueless. The waste heat of the lime-kiln is made to generate steam, and warm immense public buildings in England and on the Continent; and the "exhaust" of the steam-engine is made to do service in heating the water fed into the boiler.

I might multiply examples like the above almost indefinitely, to show how, with the most beneficent results, the genius of invention has enabled us to reap advantages where none were supposed to exist, or where, if they were suspected, they were undervalued or simply neglected.

And now, having briefly shown, by a few typical examples, what modern invention has done and is doing to utilize the waste products of nature and of the arts, I shall invite you to consider with me whether there are not waste forces in nature that can and should be turned to useful account, or to vastly better account than we are now putting them; and whether we must not plead guilty to the crime of neglecting to avail ourselves of exhaustless and incalculable stores of power that simply wait to do our bidding.

Before I pass to the consideration of what I have called the "*Waste Forces of Nature*"—by which I mean to designate such of the natural powers as the world of industry has thus far passed over altogether—it will be instructive for us to consider whether we are doing what we ought to do with those that are used, and whether, with all the inventions of our skilled mechanics and engineers, the actual practical results that we obtain from the various sources of power used in the industries do not fall far below what theory declares it to

be possible to attain. Suppose we take steam, the almost universal motive power of to-day, as an example, and put the inquiries, What ought we to get out of it and what do we get out of it? And when I am through, I think that many of my hearers, who have heretofore entertained the belief that steam-engineering was a field that had been so thoroughly worked up that but little remained to be accomplished in the direction of increasing the duty of our steam-motors, will be willing to acknowledge themselves mistaken.

To get at the practical duty of a steam-engine, we must begin with the source of the power, the steam-generator—popularly and most inappropriately called the steam-boiler; and, as the source and origin of the power generated in the boiler and directly traceable to the combustion of the fuel, it is evident that we must begin with that. Let us inquire, therefore, what power we *ought* to get from a perfect steam-engine burning pure coal, and then compare it with what we do get in the best steam-engine practice of to-day.

To understand the deductions I shall shortly make in getting at this comparison between theory and practice, I prefer to invite you to follow me through a few theoretical considerations, rather than ask you to accept the conclusions simply on my bare assertion.

It has long been known that a definite relation exists between the quantity of heat developed in a given operation and the quantity of mechanical force (manifested as work) that could be obtained from that heat. The absolute nature of this equivalency is tacitly recognized, though perhaps imperfectly comprehended in the practice of every branch of industry employing heat as a source of power; for it is this fact which establishes the dimensions of the steam-boiler, and the several proportions of the engine to do the work required of it. The steam-engine, in simple language, is simply an apparatus for turning heat into work; and it is, therefore, quite possible to express the value of a given quantity of the form of energy we call heat in terms of mechanical energy that we call "work"; and scientific investigation has established an admirable unit for this comparison in the "foot-pound"—that is, the force required to raise a pound weight to the height of one foot.

Now, to estimate the value of heat in terms of work, it was found necessary to determine the amount of mechanical force necessary to raise the sensible heat of one pound of water one degree in temperature. This amount has been carefully determined by several eminent *savants*, and has been given the name of the "mechanical equivalent of heat." The value of this constant has been found to be 772 foot-pounds—that is to say, the mechanical energy possessed by a body weighing one pound, after falling from a height of 772 feet, would, if it could all be converted into the form of energy we call heat, be exactly sufficient to raise the temperature of one pound of water 1° Fahr. (where the centigrade thermometer is employed, this constant

will have a value of $772 \times 1{\cdot}8 = 1{,}390$ foot-pounds). Now, this much having been gained in fixing the principle of our calculations, let us go back to our steam-boiler, and to the coal we feed it with. It has been experimentally determined that, if the entire quantity of heat given off during the burning of one pound of pure coal could be applied without loss to heating water, it would suffice to raise the temperature of one pound of water 7,900° C.; or, what is the same thing, differently stated, it would be sufficient to raise the temperature of 7,900 pounds of water one degree. The possible mechanical duty of the "theoretically perfect" steam-engine is found by simply multiplying the quantity which expresses the thermal equivalent of coal by the quantity which expresses the mechanical equivalent of heat, and the result would be the true value of one pound of coal burned in the boiler in "foot-pounds." Performing this simple arithmetical operation, we obtain ($7{,}900 \times 1{,}390 =$) 10,980,000 foot-pounds; or, to put it more simply, suppose we convert these foot-pounds into horse-power, which we can do by another simple arithmetical operation of dividing them by 33,000, and we shall have as a result that one pound of pure coal, burned in the perfect boiler in one minute, would, if we could apply it with absolute economy to the performance of work, exert a force of ($\frac{10980000}{33000} =$) 332 horse-power during one minute; or, if burned during an hour, then one sixtieth of 332, or 5·5 horse-power.

With a perfect boiler, therefore, we ought to get 5·5 horse-power per hour out of every pound of coal burned on the grate-bars. Now, let us inquire, What *do* we get in practice? Surely, you will say, our scientific mechanics and engineers have succeeded in getting a goodly percentage out of this possible figure; and the splendid engines, of massive construction, that work so beautifully as to excite our wonder and admiration at their smoothness and ease of their movements, must be very near perfection. Alas for the vanity of human expectations! Instead of getting 5·5 horse-power out of every pound of coal we burn in the boiler, the very best boiler and engine that have ever been constructed require two and a half pounds of coal to give out one horse-power: which means that, in spite of the vaunted progress of the mechanic arts in our times, the best engineering talent applied to the improvement of the steam-engine, from the time of James Watt down to Corliss, has only succeeded in making it yield a duty of 15 per cent. of what it ought to do, leaving an enormous margin of 85 per cent. for future improvements.

In the foregoing remarks I have, I fear, inadvertently been unjust to our engine-builders, for by far the greater portion of this 85 per cent. of wasted power is chargeable directly to the steam-boiler, and but a comparatively small proportion thereof to the engine. In considering the question of the duty of steam-motors, however, we must take the whole machine (engine and boiler), as a single apparatus. If our boiler-makers could do as well as our engine-builders—the two indus-

tries are quite separate, as you may know—the showing would be much more favorable.

It will be instructive, I think, to trace out the causes of the great waste of power that I have just pointed out, and to see if there are no means of remedying them. And if you will follow me, they will be very apparent.

The first and greatest source of loss resides in the difficulty—I may, I think, safely say the impossibility—of burning solid fuel economically in any form of furnace that has yet been devised; and this prime difficulty is an unanswerable argument in favor of the substitution of liquid or gaseous fuel for steam-making as for other purposes. Let us analyze the matter: The buyer of coal purchases at the outset at least 10 to 15 per cent. of non-combustible and useless material with every pound of coal, in the form of ash; while at least 5 per cent. more of the coal is lost by falling through the grate-bars in the form of the dust or partially burned fragments that find their way into the ash-pit unutilized. If even now, with so much waste as I have just indicated, we could really turn to useful account the whole of the thermal effect of the 85 per cent. or 80 per cent. of the combustible that we have left, we might well be content; but such is far from being the case. The furnace gases can not, by any possible mode of constructing boilers, be retained long enough in contact with the steam-generator to yield up all their heat, and they are thrown out from the chimney frequently at a temperature of 800° Fahr.; and, what is still worse, their combustion is frequently so imperfect that they carry off with them out of the chimney great volumes of unburned carbon in the form of smoke; the cold air with which the fuel is fed, and which must become highly heated before it will begin to combine with the fuel, and which abstracts this heat from the glowing coals through which it passes, is another serious item of loss, which is intensified by the necessity of frequently opening the furnace-doors when large volumes of cold air rush into the fire-space; and, lastly, the conduction and radiation of heat from the generator to surrounding objects complete the category of losses. Summing up all the items of loss in the steam-generator, it is probable that with the best forms of boilers which it has been possible to construct, not more than 25 per cent. of the theoretical thermal effect of the fuel is utilized in the generation of steam; and of this 25 per cent., from 5 to 10 per cent. is lost somewhere on the passage of the steam from the boiler to and through the engine by condensation in steam-pipes, and friction of the machinery, leaving us but 15 or 20 per cent. actually realized in practice. I beg that you will not think that I have purposely made the case of the steam-engine worse than it is; for, so far from doing so, I have actually made out the most favorable possible showing for it, by selecting for my example the best practice of the best makers.

Much of this loss, possibly the half of it, I have no hesitation in

ascribing to the use of solid fuel—coal or wood. And I take this opportunity of putting myself on record before you, as I have done for years persistently in the scientific journals, as an earnest advocate of fuel in the gaseous form, not only for industrial and manufacturing purposes, but also in the household. Let me give you a few thoughts on this subject.

The great and obvious advantage of gaseous fuel—to leave the question of its convenience, at present, out of sight—resides in the fact that the character of the fuel permits of its instantaneous and perfect intermixture with the air, by which a vastly more perfect combustion is insured—an advantage that finds admirable expression in the regenerative furnace of Siemens. Where Nature, however, supplies us with an abundance of combustible gases, as in certain favored localities in our oil regions, to which I shall have occasion to refer hereafter, an additional advantage is gained, since she has saved us the necessity of making it; and the practical utilization of the product of the numerous gas-wells of our oil regions has proved of enormous advantage to the manufacturers of these localities.

But in addition to the advantage I have just alluded to, namely, the great gain due to the more perfect combustion of gaseous fuel, there are other advantages on the score of convenience and economy that are no less important. I refer here to the saving in the carriage of coal from the yard to the place of delivery, and the recarriage of ashes—charges which are especially onerous in the numerous cases where boilers, stoves, etc., are located in the upper stories of buildings, or situated inconveniently as regards ordinary delivery by wagons. The saving in wages of stokers, to clear the fireplaces, and keep the heat of the furnace always at the proper intensity—difficulties which the adoption of gaseous fuel would entirely obviate, since it furnishes no ashes to remove—and the proper regulation of the gas supply, would insure a perfectly uniform heating effect for hours together, without supervision or attention of any kind. The incidental saving of fuel or steam, whenever, by improper regulation, or the inattention of stokers, the furnaces are allowed to become too hot; and, on the other hand, the saving in time and material that would otherwise be wasted by low fires and the frequent necessity of stoppages, until the required steam pressure is restored; and last, but not least, the great saving of fuel now universally wasted in keeping up boiler, and range, and heater, and stove fires overnight, and at all seasons—all these, and other items that I have probably overlooked in this hasty outline of the subject, form together an array of objectionable features sufficient to bring any system into disuse, where a remedy so easy to apply as the adoption of fuel in the gaseous state is at hand.

I do not wish to be understood as intimating that the use of our common burning-gas would be a panacea for all the ills I have narrated, for its cost would preclude its general adoption for industrial

purposes, to take the place of coal or wood. For domestic purposes, however, in the form of gas-stoves, even at the present high cost of this form of gas, it has been already largely adopted, and with advantage and economy; while for every form of light work, where power is only required intermittently, as in printing-offices, elevators, hoists, and the like, gas-engines, using ordinary coal-gas, are, even at present prices, decidedly more economical than steam, since they may be started and stopped instantaneously, and when idle are wasting nothing. And in the case of a steam-engine the steam must be kept up all the time, though the engine may not be wanted more than an hour or two in the day.

I look forward to the time, and I believe it is not far distant, when we shall have "heating-gas" laid through the streets of our cities and towns, side by side with lighting-gas and water-mains, and when our mills, and factories, and workshops, our parlors and kitchens, will be supplied with heat from that source, and when fires of wood and coal, with their abominations of dirt and ashes, and extravagance, will be looked upon as nuisances of the "good old times" when they knew no better.

To come back again to the subject of the steam-engine, from which I have digressed further than I had intended, I may mention the circumstance that the enormous wastefulness of this species of motor has originated the thought that electrical engines might be constructed to develop power more economically. A consideration of this topic, however, would take so much of our time this evening that I must pass it by with the brief remark that the galvanic battery can not compete in economy with the steam-engine, until some cheap mode of generating electricity shall be discovered. The fuel of the battery is zinc, and, even though we can get fifty per cent. of its theoretical power by burning it in the battery, its cost is so much higher than that of coal, the fuel of the steam-engine, that the latter has the advantage, at the present time, of forty to one on its side.

The recent great advances, however, that have been made in the construction and improvement of what are known as dynamo-electric machines, by which mechanical power, no matter how generated, whether from the steam-engine, the wind, or waterfall, could be directly converted into electricity, appear to have solved the problem of the cheap generation of electricity in any quantity, and have opened a wide field of speculation as to the possible extensive introduction of magnetic engines to take the place of steam. For I need scarcely tell you that electricity can be transmitted with but very little loss over great distances, by metallic conductors properly insulated, and made to drive magnetic engines to do the work of steam, or to furnish light for cities and towns, at pleasure. I shall take occasion to revert again to this very interesting topic in the course of the evening.

This remark brings us at length directly to the theme of my dis-

course—the "Waste Forces of Nature," to which I now invite your attention.

Of these, the first to be named, from the magnitude of the possibilities that advanced thinkers have attached to it, is that fountain of all terrestrial energy, our sun.

To introduce this topic properly, I beg to remind you at the outset that the progress of science during the last half century has been most pronounced and satisfactory in the investigation of the nature, origin, interdependence, and interconvertibility of the various manifestations of energy that are called familiarly "the forces of nature"; and among the most philosophical generalizations that the science of our times may boast of having established is the demonstration, upon the most complete and satisfactory experimental evidence, that every manifestation of terrestrial activity has more or less directly a solar origin. Every exhibition of force, physical or chemical, inorganic or vital, the multifarious consequences connected with the circulation of air and water over the surface of the earth, and in her oceans, and which involve the causation of the winds, aërial and aqueous currents, and rainfall, and the effects of these commonplace but vastly important phenomena in establishing and maintaining those climatic conditions upon which the existence of life upon the earth is absolutely dependent, are directly referable to the forces of solar radiation. Ay, there is good reason for the belief, which is entertained by most competent and eminent authorities, that the periodical recurrence of famines and pestilences and other scourges that afflict mankind, and which the superstitious of all ages are wont to ascribe to the anger of an offended deity, coincides with the periodical maxima and minima in the intensity of the solar emanations that reach the earth; and that even such apparently disconnected and arbitrary things as the social and political affairs of mankind, which are intimately bound up with the successful pursuit of agriculture and commerce, are therefore demonstrably under the direct and immediate dominion of the solar rays.

But, to return from a digression that is only of incidental interest to us here, I desire you to conceive of the amazing fact that the stupendous aggregate of terrestrial activity is derived from that infinitesimal fraction only of the solar emanations that is intercepted by the earth—a fraction less than the two-billionth part of the sum total of energy that he is unceasingly radiating into space; and it is my immediate purpose here to invite your attention to the interesting question whether it is within human reach to convert a portion of the measureless floods of power that the sun pours out upon the earth into mechanical energy, or into other forms in which it will be more directly available for useful purposes.

The proposition here announced, I must advise you, is not the visionary notion of impracticable theorists, but is one that, on the con-

trary, has seriously occupied the attention of such eminent practical engineers and mechanics as Ericsson, and others scarcely less widely and favorably known; and, although up to the present time nothing very tangible has resulted from their labors, they have at least succeeded in demonstrating, beyond reasonable doubt, that the problem is susceptible of practical solution.

To convey some adequate notion of the incalculable floods of power that await the bidding of the compelling genius of invention, I will invite your attention to a very brief *résumé* of the well-substantiated results of scientific research applied to the subject. The French physicist Pouillet, with the aid of elaborately refined apparatus, estimated that the earth receives from the sun in each and every minute 2,247 billions of units of heat—a quantity sufficient, if converted into mechanical force, to raise 2,247 billions × 774 pounds to the height of one foot. To come down to figures that are less difficult of conception, let us confine our attention to that part of the solar heat that falls upon the oceans, and to the fraction of that portion which is expended in the work of evaporating the water.

Without entering into an explanation of the modes in which the following calculations have been made, and which would run into far greater length than the limited time at my disposal this evening would warrant, I will simply give you the results.

I have said, you will remember, that we would confine our attention to that portion of the solar heat that falls upon the oceans, and to that fraction of it which is expended in the work of evaporating the water; in doing which alone, the sun raises during every minute an average of not less than 2,000,000,000 tons of water to a height of 3½ miles—the mean altitude of the clouds. To express this prodigious exercise of power in more familiar form, I may put it this way, that to continuously raise this weight of water to the height of 3½ miles per minute would require the continuous exercise of the force of 2,757,000,000,000 horses per minute.

Here, then, is power enough to satisfy the most enthusiastic inventor, and leave him plenty of margin; and if the believers in the sun-engine shall ever succeed in giving mechanical expression to but the merest fraction of this superabundance, they may safely count upon creating as profound a revolution in the world of industry as that which was ushered in with the steam-engine.

Ericsson, who has devoted much study to this enticing problem, has announced his unqualified belief that the sun-engine is practicable. He has progressed so far as to lay down the general principles on which he proposes to construct such a motor, and which he has actually put into practice in the production of an engine that runs with great uniformity at a speed of 240 revolutions per minute, and consuming at this rate only part of the steam made by the solar generator employed. From the very brief and imperfect accounts that have

been made public, it appears that the Ericsson sun-engine is composed of three distinct parts—the engine proper, that is, the working mechanism, the steam-generator, and the concentrating apparatus, by means of which last the feeble intensity of the sun's rays is augmented to the degree that will suffice to produce steam at a practical working pressure.

He claims that this concentrating apparatus will abstract on the average, for all latitudes between 45° north and 45° south, fully 3½ heat-units for every square foot presented vertically to the sun's rays. With 100 square feet of surface in his concentrating apparatus, therefore, he believes it will be possible to continuously develop from the sun's rays 8·2 horse-power during nine hours within the above-named range of latitude.

Mouchot, who, so far as the practical construction of the solar engine is concerned, has progressed further even than Ericsson, exhibited at the late Exposition at Paris a working sun-engine upon substantially the same general principle of construction as that above described, and which, from its novelty and the importance of the principle it illustrated, received universal popular attention and a most encouraging and flattering report of the judges of awards.

Not to over-estimate the capabilities of the new system, Ericsson, in his consideration of the practical side of the subject, assumes that a sun-engine of one horse-power will demand the concentration of heat from one hundred square feet; and on this estimate he proceeds to show that in all reasonable probability those regions of the earth that now suffer from an excess of heat will some day derive such benefits from their unlimited command of motive power as to vastly overbalance their climatic disadvantages. He proposes the sun-engine only for those regions where there is steady sunshine, and has mapped out extensive tracts of land aggregating no less than 9,000 miles in length and 1,000 miles in breadth, including therein the southern coast of the Mediterranean, Upper Egypt, much of the Red Sea region, the greater part of Persia and Arabia, and portions of China, Thibet, and Mongolia, in the Eastern Hemisphere; and Lower California, the Mexican plateau, Guatemala, and the west coast of South America for a distance of 2,000 miles, as the field of the solar empire of the future. As an evidence of the sincerity of his belief in the realization of these ideas, let me quote you the following enthusiastic passage from one of his numerous essays upon this subject: "The time will come," asserts Ericsson, "when Europe must stop her mills and factories for want of coal. Upper Egypt then, with her never-ceasing sun-power, will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the sides of the alluvial plain of the Nile, where sufficient power can be obtained to enable him to run more spindles than a hundred Manchesters."

For centuries past the wind has been put to work with very good

results, and in some countries, notably in Holland, quite extensively. From the best advices I have upon this topic I have it that there are in that country no less than 12,000 windmills, averaging eight horse-power each, giving a total of 96,000 horse-power.

The chief and obvious difficulties that intrude themselves against the extensive use of the wind as a motive power for general industrial uses are that in most locations it is intermittent in its action, extremely variable as to its power, and quite unreliable as to the time and duration of its manifestations.

The immense power stored up in this unfortunately unreliable agent will appear from the statement that a wind of three miles per hour travels 4·40 feet per second, and exerts a pressure of 0·32 to 0·44 pound per square foot of surface opposed to its action. A wind of twenty-five miles an hour, or what sailors would call a good stiff breeze, travels 39·67 feet per second, and exerts a pressure of from 2·208 to 3·075 pounds per square foot. The prodigious energy of a hurricane, traveling not infrequently at the rate of one hundred miles per hour, is too well known by its disastrous effects to need repetition. The power of the wind, however, save for ship-propulsion, is utilized in but few situations, its unreliability having caused it to be but very slightly esteemed in comparison with water-power and steam. Of late, however, small windmills, especially designed with superior mechanical skill, have been rapidly growing in popularity in this country, mainly for pumping water for railway and domestic purposes, an application for which these devices are excellently adapted; and I entertain no doubt that there are many situations where work is to be done that does not demand a continuous exercise of power, and where the prime consideration to be observed is the element of cheapness, where wind-power might be most advantageously employed. There are, again, extensive regions of the earth, extending for ten or more degrees north and south of the equator, where the winds blow continuously from one direction throughout the greater portion of the year—I need hardly remind you that I refer to the region of the "trade-winds," and in which, especially along the coast-line where their influence is not disturbed by mountain ranges and other conflicting causes, the force of the wind may be relied upon with almost absolute certainty for the whole or the greater portion of the year. In such regions, therefore, Nature has supplied us with an exhaustless store of energy, capable of meeting the most extravagant demands that may be made upon it. Even the region of the temperate zones, where the winds are variable, our seashores have their strong land- and sea-breezes which for nine days out of ten may be relied upon; and even in situations where wind-power is most unreliable, as in the interior of the continents, there is a vast and valuable field open for some practical and generally applicable system by which the power of the wind, at present almost universally allowed to go to waste, may be stored up to be given out again as it

may be required for service; for it may be made to coil a spring, to raise heavy weights, or lift water into elevated reservoirs, or, by other simple devices well known to the mechanical engineer, to store up its power, which may be subsequently given out through machines especially adapted for the purpose.

The tides ebbing and flowing twice daily, lifting upon their bosom, like so many corks, the heaviest vessels, and baffling all efforts to restrain their resistless force, afford us another instructive topic for consideration in treating of the wasted forces of Nature—for here, again, she has lavished out of her superabundance infinitely more power than any conceivable increase of the needs and industries of man could ever employ.

The rise and fall of the tides vary, according to local conditions, from a few inches, as in the Mediterranean Sea, to seventy feet, as in the Bay of Fundy, and their force in almost any one of our rivers would, if properly applied, suffice to furnish ample power to all the mills and factories and workshops that could be built side by side upon their banks. They would drive under-shot wheels unfailingly. Where there are extensive meadows regularly overflowed, as they commonly exist along all of our larger streams, a levee containing two sluices, each supplied with a turbine water-wheel, one to be driven by the ebb and the other by the flow, could be made to utilize incalculable power.

In some exceptionally favorable localities, where the conditions have forced themselves upon the attention of observing and practical men, tide-motors have been introduced, and with great advantage; but the general utilization of these exhaustless and continuous stores of energy still remains to be accomplished.

Great rivers above tide-water are rolling down a wealth of power in their currents; and a hundred factories along their banks, heedless of the fact, are using steam-power. And it is one of the standing marvels that manufacturers fail to recognize the elementary fact in mechanics, that it is not necessary for a stream to have from ten to two hundred feet of fall, in order to do their work; while the great rivers upon whose banks their workshops are perched are permitted heedlessly to pour out trillions of cubic feet of water, year after year, into the ocean, opposing no mechanical difficulties in the way of yielding up their inexhaustible supplies of power.

Who may estimate the wealth of power poured out in unheeded profusion by our great waterfalls from Niagara down? Confining our attention to the one grand cataract, try to conceive of two million tons of water per minute hurled down that ledge of rock, representing 56,000 horse-power expended every minute in the work of disintegrating and undermining the rocky river-bed below. A few tiny paddles, I am told, dip into the current above the falls, and drive a paper-mill, but what of the millions of horse-power that are allowed

to run heedlessly to waste down that great fall of 157 feet, in a sheet twenty feet thick and 4,750 feet broad?

The gas-wells of the oil regions have been permitted to spout away wealth enough to have repaid a hundred-fold all the money ever lost in oil speculations; but it is gratifying to be able to say that the great value of these natural supplies of heat and light is now very generally recognized, and that in many localities the gas is turned to useful account in supplying light and heat to towns and cities and factories and mills.

In some of the cases that I have called to your attention, the power is steady and unremitting, in others it is too violent or too uncertain for direct application. In the first instance, uses for the power may be found at once; in the last, means for storing it up must be provided, and would, beyond question, abundantly repay the undertaking. For this purpose, the raising of weights or of water into elevated reservoirs, and the compressing of air, afford two simple and ready means of storing up power to be let loose as required; while other means of a mechanical nature to accomplish the same purpose will readily occur to my mechanical hearers.

While upon this point, I must not omit to state one fact of the greatest interest that is now attracting the attention of some of the highest living authorities. I refer to the question of the practicability of transmitting mechanical power to great distances by converting it into electricity, through the agency of what are called dynamo-electric machines, and utilizing this either for the production of powerful lights for illuminating cities and towns, or by converting it back again into mechanical power with the aid of magneto-electric engines, by which mills, factories, and workshops may be furnished with the power they now obtain from steam or water. It will be very *à propos*, in this connection, to notice that the feasibility of transmitting to great distances the almost incredible power of Niagara Falls, by some such means as that above named, has been affirmed by many scientific investigators of eminence.

Dr. C. W. Siemens, in his presidential address before the last meeting of the Iron and Steel Institute, in touching upon the highly interesting subject of the employment of electricity as a substitute for steam, made the following instructive statements: He declared that so long as the source of electrical power depended upon the galvanic battery, it must, in the present state of things, remain far more expensive than steam-power, for the obvious reason that zinc, which is the fuel of the galvanic battery, is vastly more expensive than coal, the fuel of the steam-boiler. If, however, continues Dr. Siemens, a natural force, such as water-power, mark you, could be utilized to generate electricity economically, the case would be very different. A dynamo-electric machine actuated by water-power could be made to generate powerful electrical currents, which could be transmitted through insu-

lated metallic wires or cables to a great distance with but little loss, comparatively speaking, and could thus be made to run magneto-electric engines to do the work of steam in our mills and workshops, to ignite electric lamps, etc. A copper rod, or cable, three inches in diameter, says Dr. Siemens, would be capable of transmitting a thousand horse-power to a distance of say thirty miles—an amount sufficient to give the light of a quarter million of candles, and suffice to illuminate a town of moderate size. Two eminent American investigators, Professors Houston and Thomson, of Philadelphia, having just made an investigation with the especial purpose of determining the practicability of transmitting the power of Niagara to great distances by means of electricity, go even further than Dr. Siemens. They make the astonishing assertion—and, what is more, they prove it—that it would be possible, should it prove to be desirable, to convey the whole power of Niagara to the distance of 500 miles or more by means of a copper cable not exceeding a half inch in thickness.

It is unnecessary for me to multiply examples upon this fruitful theme of speculation, for the time admonishes me that I have already trespassed sufficiently upon your attention, and I think I have convinced you very fully that such queries as What shall we do when our coal-fields are exhausted? need cause us no anxiety, for centuries before this possibility shall be realized, I opine, the world will no longer stand in need of them.

THE GEOLOGICAL SURVEY OF THE FORTIETH PARALLEL.

By Professor J. S. NEWBERRY.

THE geological survey of the country bordering the fortieth parallel of latitude was made under the direction of the War Department by a party under Mr. Clarence King, who took the field in 1867. The area covered by the survey was a belt one hundred miles wide, traversed by the Pacific Railroad between the Great Plains on the east and the Sierra Nevada on the west, approximately between the 104th and 120th meridians of longitude. The general object of the survey was to connect the region of which the geological structure has been made known through the California survey on the west with the explored portion of the Mississippi Valley, and thus to supply the material for completing a section across the continent. In addition to this it was proposed to determine by careful investigation the structure and resources of the country lying adjacent to the Pacific Railroad, which by the construction of this great work was opened to occupation, and was already invaded by a population eager to seize and develop its hidden stores of mineral wealth.

Mr. King chose as his geological assistants the brothers J. D. and Arnold Hague, and S. F. Emmons, all of whom had received good training in the geological survey of California, and proved competent and congenial co-laborers with him. Specialists were also engaged to study the materials collected in other departments of natural science; the fossils being placed in the hands of Mr. F. B. Meek, and, after his death, in those of Professor James Hall and Mr. R. P. Whitfield. The botanist of the survey was Mr. Sereno Watson, and the ornithologist Mr. Robert Ridgway, while a special investigation of the volcanic rocks collected was made by Professor Ferdinand Zirkel, the distinguished lithologist of Leipsic. The topographical work of the survey was, during the greater part of its continuance, in charge of Mr. J. T. Gardner, now director of the Topographical Survey of the State of New York.

The report of the "Survey of the Fortieth Parallel," as now published, consists of six volumes quarto. Of these the first issued (1870) was Vol. III. of the series, entitled "Mining Industry," and devoted to a description and discussion of the important mines and mining districts embraced in the territory studied. About half of the volume is taken up with a detailed description of the Comstock lode—the most productive deposit of gold and silver yet discovered—and of the methods of exploitation followed in the different mines located upon it, by Mr. King and J. D. Hague. It also contains chapters by Mr. Arnold Hague on the "Chemistry of the Washoe Silver Process," and on the "Geology of the White Pine Mining District"; the "Geology of the Toyabe Range," by S. F. Emmons; and on the "Geological Distribution of Mining Districts," and the "Green River Coal Basin," by Mr. King. This volume is accompanied by an atlas of maps, plans, and sections, which at the time of its appearance was by far the most beautiful work of its kind published in this country.

It is greatly to be regretted that the review of the mining industry of the country bordering the Pacific Railroad, so admirably begun in this volume, could not have been continued through the life of the survey, and have been presented to the public at its close. Since the publication of this discussion of the Comstock lode, the most important chapters in its history have been enacted, and it is a pity they should not also have been written. When Mr. King closed his examination the workings had reached a depth of a little more than 1,000 feet, and the maximum temperature (of water at bottom) was about 108° Fahr.; and now the depth of 2,500 feet has been reached, the temperature of the water at the bottom is 160°, and facts have been obtained which indicate that the limits of the successful working of the lode will be determined by temperature and these limits soon be reached.

The Sutro Tunnel has also been constructed and all its geological revelations made since the appearance of Vol. III. The great bubbles of the White Pine and the Emma mines have since swollen and burst,

and the important litigation between the Eureka and Richmond has been decided on geological grounds; and yet the public has nowhere received the information which it craves as to how it has happened that so many millions have been made from the Comstock mines (by their managers), and so many lost in the White Pine and Emma. The great bonanzas of the California and Consolidated Virginia have nowhere been fully described. A few geologists know that they are simply disconnected patches of rich ore, such as lie in most fissure veins; but the public at large have either no ideas at all about them, or those that are wide of the truth. So we may search in vain through all mining literature for the simple explanation of the problem involved in the Eureka litigation, and in the ephemeral productiveness of the White Pine and Emma, viz., that these mineral deposits are chambers or galleries formed in limestone *beds* by atmospheric water carrying carbonic acid, and subsequently occupied with ore deposited from ascending solutions which filled these cavities, just as elsewhere the simple crevices of fissure veins.

If any one can imagine the lead-bearing limestones of Missouri or the honeycombed plateau of central Kentucky broken up by volcanic action, the strata set at high angles, and their irregular cavities filled with mineral solutions issuing through fissures from below, he will get a just view of the nature and origin of these mysterious ore deposits, and a ready explanation of their irregular and superficial character.

If Mr. King could have continued his observations on the Comstock, and had investigated all the mineral deposits discovered along this rich belt, so freely opened by the active exploitation of the last ten years, in the same thorough way that he did the Comstock, he would have made a contribution to American geological literature which would have been of great scientific interest, and of a pecuniary value to mine-owners and mine-buyers to be reckoned in millions.

Vol. V. made its appearance in 1871; it was devoted to Botany, and was prepared by Mr. Sereno Watson, with the assistance of a number of our best botanists, who have made special studies of particular families of plants; as Engelmann of the *Cactaceæ*, Eaton of the Ferns, Tuckerman of the Lichens, etc. Vol. VI., on Microscopic Petrography, by Professor Ferdinand Zirkel, was published in 1876; Vol. IV., on Paleontology and Ornithology, in 1877; Vol. II., which embraces detailed reports by Messrs. Arnold Hague and S. F. Emmons, on the local geology of the belt of territory surveyed, also appeared in the same year; and, finally, Vol. I., written by Mr. King himself, forming a comprehensive review of the systematic geology of the country covered by his explorations, has only just now left the binder's hands.

The magnificent geological atlas intended to accompany and illustrate the reports of the "Survey of the Fortieth Parallel" was issued in 1876. This will compare favorably with any work of its kind done in the Old World, and at the time of its publication it far excelled

anything which had before been attempted in this country. To the good taste and the technical skill of Mr. Julius Bien, of New York, Mr. King is largely indebted for the beauty and accuracy of this atlas; and it may be a matter of general congratulation among American geologists that it was then demonstrated that the cartographic art had been carried to as great perfection here as anywhere else in the world, and that all known refinements of graphic illustration are within their reach.

All the volumes of the "Report of the Fortieth Parallel Survey," except Vol. I., have been more or less thoroughly reviewed in the scientific journals, and it is therefore unnecessary that they should receive further notice here. It is but just, however, to say of the general character of the report of Mr. King, now for the first time collectively exhibited, that it takes high rank in the literature of the subjects which it considers, and is most creditable to the chief under whose direction the work here recorded was executed, and to his assistants, both for the great amount and excellent quality of that work, and from the good taste and care which the volumes and maps display.

Perhaps no other geologist has enjoyed the opportunity of directing the exploration of so wide and interesting a field, has been so independent and untrammeled in his action, and has had such resources at his command as Mr. King; and something of his success should be ascribed to his good fortune. Yet it is true that he has made excellent use of his exceptional opportunities, and the result can not in justice but be regarded as alike honorable to him, to the War Department under whose auspices the survey was made, and to the country.

In the volume just issued Mr. King has discussed the exposures of all the different systems of rocks which form the geological column, beginning with the Archæan and ending with the Quaternary. He then takes up the volcanic rocks, of which there is such an immense display in the western part of his field, and discusses their relations, succession, and classification. His last chapter is devoted to orography, and is a study of the different and very numerous mountain chains and axes of elevation which occupy so much of the region he has studied. In the progress of this review he has not only made great and important additions to what was before known of the distribution and development of the different geological formations throughout the West, but has subjected each group of rocks and each important topographical feature to close and careful study, with the view of evolving from its ascertained structure the details of its history. In these investigations he has touched upon some of the most profound problems that have engaged the attention of geologists and physicists; and while we can not assert, and he will hardly claim, that all the conclusions he has reached will be confirmed by further observation and mathematical analysis—for all human work is imperfect—yet it can not be denied that the facts he has reported and the inductions he has

proposed will have an important influence on the progress of geology, especially in this country.

The publication of Mr. King's volume certainly throws a flood of light on the complicated and hitherto somewhat chaotic geology of our Western Territories, and it can not fail to afford important aid in the proper orientation of both observers and observations in all the great region west of the Mississippi.

It is evident that nothing like a thorough discussion of the facts and conclusions contained in Mr. King's great volume of eight hundred quarto pages can be given here; but some of the most important of his facts, and the more interesting of his generalizations, will be briefly noticed in the succeeding pages.

ARCHÆAN.—By this term, which he accepts from Dana, Mr. King designates all the great mass of crystalline schists and granitoid rocks which underlie the Cambrian system, and form the base of his grand section. These are most fully exposed in the Park and Medicine Bow Ranges of Colorado and Wyoming, and in the Humboldt and Truckee Mountains of Nevada; but there are also numerous minor ranges and summits composed of granitoid rocks, especially west of Salt Lake; and Mr. King shows that these latter exposures are portions of a broad pre-Cambrian land-surface which formed the western border of a great topographical basin that reached to the Rocky Mountains on the east. This basin was occupied by the seas from which were deposited the Palæozoic rocks. These latter were largely derived from the erosion of the neighboring land on the west, and formed a conformable series, of which the estimated thickness is over 30,000 feet. The old land which supplied the mechanical material of the Palæozoic strata extended to an unknown distance northward, and reached southward at least to the present head of the Gulf of California, in a region where it was recognized by the writer, and its relations to the Palæozoic series of the Colorado plateau pointed out in the "Report of the Colorado Exploration," 1861.

Mr. King divides the Archæan rocks into two great groups, of which the first consists at base of gray or flesh-colored bedded granite, overlain by red, massive granite, on which lie red, micaceous, bedded granites, the whole attaining a thickness of perhaps 25,000 feet. This group is characterized by the presence of quartz, orthoclase, and oligoclase feldspars, with a little hornblende and mica, the latter consisting of biotite, muscovite, and lepidomelane. It also contains more or less labradorite, titaniferous iron, magnetite, and graphite, the whole corresponding closely with the Laurentian of Canada.

The upper subdivision of Archæan rocks—found in the Medicine Bow and Park Ranges, the Uintah, Wahsatch, Humboldt Mountains, etc.—consists of true gneisses, interstratified with mica schists, often garnetiferous, hornblende schist, sometimes with zircon, etc., all very distinctly, often minutely stratified. The thickness of this group is in

the Wahsatch and Humboldt Mountains, from 12,000 to 14,000 feet, in the Park and Medicine Bow Ranges somewhat less, and in the Clear Creek region of Colorado at least 25,000 feet. This upper group will be recognized by geologists as closely resembling the Huronian rocks of the East. The Archæan nucleus of the Black Hills was reported by the late Mr. Henry Newton to be composed of two groups of crystalline rocks closely resembling those described by Mr. King, and Mr. George M. Dawson found a similar double series in Manitoba and British Columbia. Without absolute proof—which it would be difficult if not impossible to obtain—the inference is at least allowable that the rocks underlying the Palæozoic series in the far West correspond to the Laurentian and Huronian Groups of the Canadian geologists, and therefore that the foundation of the western half of the continent is essentially the same with that of the eastern; and also that there, as here, a broad continental surface of these older rocks supplied by erosion the mechanical material that entered into the composition of the Palæozoic sediments, which, by successive oscillations of sea-level, were spread to varying altitudes upon its flanks.

At the close of his chapter on the Archæan, Mr. King proposes a theory of the genesis of granite and crystalline schists, which is in some respects new. In common with most of the geologists of the present day, he supposes that the granites and schists are sedimentary rocks which, having locally accumulated to great thickness, have sunk by their own weight into the yielding crust of the earth to a point where they have suffered more or less aqueo-igneous softening, and then, in his view, under varying intensities of radial and tangential pressure, they have been converted into corrugated schists or massive granite, according to the less or greater energy of the forces acting upon them. The evidence adduced by Mr. King to support this mechanical theory of the origin of granite is chiefly derived from the facts which indicate internal and bodily movement in granite, such as the dislocation of inclosed minerals, and the inclusion of masses of foreign rocks.

That there has sometimes been more movement in granites than in the schists with which they are associated—and of which they can frequently be shown to be the exact equivalents in a more metamorphosed condition—is quite certain; but it is very difficult to separate here the effects of force from those of heat. Either produces the practical plasticity which we see recorded in the obliteration of bedding, and the inclusion of foreign rocks. Granites, which exhibit the extreme phase of metamorphism, have evidently been in a plastic state, for they have been forced into fissures of other rocks to form veins and extruded mountain-crests—proofs of softening and movement which schists never afford—but whether this plasticity was the effect of greater heat or greater force than the associated schists suffered, is a question not answered by any facts yet cited. The dislocation of included min-

erals indicates force; the inclosure of blocks of foreign material, when these blocks are masses of metamorphic schists, indicates plasticity, but affords no test of temperature. Where the included blocks are limestone, as in the granite of the Pyrenees described by Green ("Physical Geology," p. 322), and these blocks are externally metamorphosed, internally unchanged, we have a record of softening and heat, but not the heat of fusion. The coarser crystallization of granite means that it has been more or longer softened, so that its component minerals were free to crystallize out; but no distortion or dislocation of these minerals affords stronger proof of internal movement than is furnished by the associated schists, in which the fossils often not wholly obliterated are quite as much distorted as any minerals in the granite. The inclusion in granite of blocks of slate which have been transported some distance from their place of origin, supplies, however, conclusive evidence of movement which may even be called a flow. Cases of this kind, which are of great interest and significance, were observed by Mr. Newton in the Black Hills. The granite core of this mountain-chain incloses large angular blocks of metamorphic slate which have been torn from their connections and carried bodily upward. The granite also shows a kind of slickenside-jointing, which proves that when in a plastic but not fused condition it was squeezed out of a fissure or opening in the harder overlying schists. We have here proof that the granite in its lower position has been more *softened* than the schists, and that it has been more moved; but we have no proof that it has been subjected to greater pressure.

In contrast with the theory of Mr. King, that granites have been produced by great pressure, is that promulgated by Mr. H. F. Walling (Proceedings of the American Association at the St. Louis meeting), in which lateral pressure is practically ignored as a cause of metamorphism. Mr. Walling, supposing, with others, that sediments accumulating along shores have sunk by their gravity, recognizing the fact that the static equilibrium must be maintained by the rising of the areas lightened by erosion in the removal of these sediments, attributes mountain elevation to this ascent, and the corrugation of metamorphosed rocks to the lateral flow of material from the sinking to the rising areas. There is certainly great force in the reasoning used by Mr. Walling to show that there must be rising as well as sinking areas, and a subterranean flow of matter from one to the other to compensate for the transfer of eroded material on the surface; but it seems doubtful whether the traction produced by the adhesion of the solid strata above to the moving mass below could produce slaty cleavage and other phenomena, which we have been accustomed to attribute to the lateral thrust produced by the crushing down of the rigid crust on a shrinking nucleus. It is hardly necessary to say that the metamorphism of granite is, according to Mr. Walling, due to the subterranean heat to which it has been exposed in its descent far below the surface.

Probably the final conclusion reached in the discussion of the origin of granites, to which Mr. King has certainly contributed many new and interesting facts, will be that each of the causes, heat and pressure, should be credited with a share of the effects produced.

PALÆOZOIC.—One of the most interesting and surprising results of Mr. King's exploration is the discovery of a section of stratified and unmetamorphosed strata said to be conformable throughout, reaching from the base of the Cambrian to the top of the Carboniferous, and attaining a maximum thickness of 32,000 feet. No section of the Palæozoic rocks of equal magnitude has yet been discovered elsewhere in the world, and the announcement will doubtless be received with some incredulity by geologists, but the accuracy with which the measurements were taken by Mr. King and his assistants, and the vindication of his classification afforded by the fossils, which were carefully reviewed by Mr. Meek, Professor Hall, and Mr. Whitfield, seem to leave no room for doubt. This great group of rocks is said, as before stated, to have been laid down in a basin bounded on the east by the ranges of the Rocky Mountains in Colorado, and on the west by a broad archæan area in Nevada. In the middle rose the lofty islands of the Wahsatch, which toward the west presented an abrupt slope of 30,000 feet, against which the Palæozoic rocks abutted. From the inclosed character of this sea most of the sediments formed in it are mechanical, and represent the wash from the adjacent land, but in the middle of the section occurs what Mr. King calls the *Wahsatch limestone* (Lower Carboniferous and Upper Devonian), seven thousand feet in thickness. Although no certain measure of time is afforded by the mechanical sediments—since the rapidity with which they were deposited may have varied indefinitely with the activity of eroding agents—this great limestone mass, formed as it must have been through organic agencies, represents a lapse of time which is almost beyond the reach of the imagination; and if, as Mr. King states, the Palæozoic series is essentially conformable throughout the area it occupies, we have here evidence of a stability in the physical conditions of this portion of the earth's surface, which, so far as known, is without parallel.

Mr. King gives two sections of the Palæozoic series taken, one in the Wahsatch Mountains and the other in Middle Nevada, which differ only in minor details. The Wahsatch section is, however, the most complete, as it shows the base of the Cambrian system, which is not visible farther west; it is as follows:

1. Permian	615	feet.
2. Upper Coal Measure limestone	2,000	"
3. Weber quartzite, Carboniferous, and Devonian	6,000	"
4. Wahsatch limestone, Carboniferous, and Devonian	7,000	"
5. Ogden quartzite, Devonian	1,000	"
6. Ute limestone, Silurian	1,000	"
7. Cambrian siliceous schists	11,000	"
8. Cambrian slates	800	"

Mesozoic.—At the close of the Palæozoic ages great changes took place in the topography of the central and western portions of the continent, all of which are for the first time made clearly known by Mr. King's graphic and lucid descriptions in his chapters on the "Mesozoic Areas of the Fortieth Parallel." After the deposition of the great and conformable series of Palæozoic rocks in the central basin, the Archæan continent, which formed the western limit of these older deposits, and which had continued dry land to the close of the Carboniferous age, was sunk under the waves of the Pacific, and thus remained during the Triassic and Jurassic ages—long enough for the deposition of about 20,000 feet of sediments, of which considerably more than half belong to the Trias. Then the great fold of the Sierra Nevada was raised high above the ocean-level, carrying with it all the table-land of the Great Basin, which has not since been covered with salt-water. The rocks composing the Sierra Nevada are chiefly the Jurassic and Triassic beds, here often completely metamorphosed and converted into crystalline slates and massive granites, in which lie the auriferous veins that have supplied the $1,000,000,000 of gold already taken from the California placers and quartz mines. This paroxysm, or rather period of elevation, occurred before the Cretaceous age; for, in all the interval between the Wahsatch and the Sierra Nevada, no Cretaceous rocks are found. On the Pacific side of the great Sierra, however, Cretaceous strata lie nearly horizontal, abutting against the upturned Jurassic and Triassic slates, and reaching to a height of some 1,200 feet above the present ocean-level.

East of the Wahsatch a very different history is recorded, for here the Triassic, Jurassic, and Cretaceous strata were deposited not only in a series conformable among themselves, but apparently with the Palæozoic rocks below. This conformability is, however, more apparent than real, for the region between the Wahsatch and the Mississippi gives abundant evidence of elevation and subsidence during the Mesozoic ages; but these changes of level were continental rather than local, and over an area of hundreds of thousands of square miles the surface on which the strata were deposited was so nearly level that no want of parallelism in their planes of deposition is visible to the eye. That great changes of level did take place in this region is evident from the facts, first, that on the area over which the Triassic beds were deposited, extending from the Colorado to the Mississippi, mechanical and shallow water deposits alone prevail. No limestones occur here in the Trias, but it is made up of great sheets of cross-stratified and tide-swept sand of brilliant colors, chiefly bright red—due to the complete oxidation of their iron from aëration, and the absence of organic matter—with here and there heavy beds of gypsum, and formerly of salt; all the records of the intermittent action of a shallow sea. This sea-bottom over the interval between the Rocky Mountains and the Mississippi became dry land at the close of the Trias; for the Jurassic

strata which occupy much of Colorado, Utah, and Nevada, scarcely reach eastward beyond the mountains; and the Cretaceous age was marked by a great submergence which carried the shore-line progressively from the Gulf of Mexico to the Wahsatch, and northward, perhaps, to the Arctic Sea, converting all the area between the Wahsatch Mountains and the Canadian highlands into a sea, in which were deposited in some places 2,000 feet of limestone, the slow accumulation of calcareous matter from the growth and decay of marine organisms.

From Mr. King's careful study of the Mesozoic rocks of Nevada, we learn that the Trias consists of alternations of limestone and quartzite, which, in Star Peak, form a continuous section of over 10,000 feet. The fossils which the limestones contain show that much the larger part of this mass belongs to the Alpen Trias of the Old World, the Halstadt and Saint Cassian beds, and those which form the passage to the Jura.

The Jurassic rocks of Nevada are mostly shales—the deposits from water too shallow for limestones—and contain few fossils. Along the eastern margin of the Jurassic area in the Black Hills, the Jurassic beds are more purely marine, and are far richer in fossils. The upper portion of these beds, which are of an estuarine or littoral character, has lately been discovered to be a vast cemetery of vertebrate animals, some of which are of unequaled size, and in their structure of special interest. Among these are the huge dinosaurs described by Marsh and Cope, some of which far exceed in dimensions any terrestrial animals before known, the largest, according to Marsh, having a length of at least one hundred feet, and a height of twenty-five or thirty.

The uppermost member of Mr. King's Mesozoic section is the somewhat famous *Laramie group*—the Lignitic formation of Dana, so named because it contains the most important coal-beds of Colorado. The age of this group of rocks has been much discussed by Dr. Hayden and Lesquereux, the distinguished fossil botanist, and it has been represented by them to be Tertiary, on the evidence of its numerous fossil plants; Cope, however, found the remains of Cretaceous vertebrates, and Meek, Cretaceous mollusks, in it; and hence it was said to have a Cretaceous fauna and a Tertiary flora. The writer has, however, for a long time contended that its flora was distinct from that of the Tertiary rocks, and the proof was stronger that it was Cretaceous. Mr. King adduces new and apparently conclusive evidence that it is older than the Tertiary, since, like Cope, Meek, and Stevenson, he has obtained numerous Cretaceous animal remains from it, and finds it to underlie unconformably the Coryphodon beds, the oldest portion of the Eocene.

TERTIARY.—The pictures which geology presents to us of the far West during the Tertiary age are totally different from those which preceded them, and, on the whole, more varied and interesting. As

we learn from various sources, at the close of the Cretaceous the widespread sea of that age was withdrawn from the interior of the continent, and all the interval between the Sierra Nevada and the Canadian highlands became a land-surface, while in the lower valley of the Mississippi, and on the Gulf and Atlantic coasts of the eastern half of the continent, the sea stood higher than before or now, for marine Tertiary strata form a broad marginal belt reaching around the old land from New York to and up into the Mississippi Valley. In the region of the Plains, the Rocky Mountains, and the Great Basin, however, we find no marine Tertiaries, but abundant evidence that, instead of the former sea-surface, a broad continental area stretched from the Arctic Ocean southward through and beyond the Territories of the United States. This continent was marked by few bold topographical features, since the Rocky Mountain system was then slowly growing, and had attained nothing like its present magnitude. The surface was, however, varied with low mountain-chains, broad savannas, strongly flowing rivers, and a series of fresh-water lakes, which in magnitude far exceeded any now on the earth's surface. The climate was mild and genial even to the North Sea, and the land was clothed with a vegetation more luxuriant and varied than that which it now bears. Of the magnitude of its forest growth we have evidence not only in the abundant remains of trunk and leaf and fruit imbedded in the old lake sediments, but in the scattered remnants of its former grandeur seen in the gigantic conifers of California, and in the cypress, magnolias, sweet gums and sycamores, which are the pride of our Eastern forests. This fertile land also sustained a fauna corresponding in richness and interest to its flora; for in the Tertiary the gigantic reptiles of the Mesozoic were succeeded by herds of mammals which far surpassed in numbers, size, and variety of species, any mammalian fauna now living. Their remains have been exhumed by thousands from the old lake-beds, where, in the long lapse of ages, they had been borne by river-floods and entombed. Thus were formed the vast charnel-houses from which Leidy, Marsh, and Cope, have drawn the treasures they have exhibited to the admiring scientific world. One after another of those great Tertiary lakes were created by topographical changes which established hydrographic basins, and, in turn, by the cutting down of their outlets, their beds were first made dry land, and afterward deeply cut by the many-branched draining streams, until they have formed the *Mauvaises Terres* or "Bad Lands" of the West.

The Tertiary deposits, then, cf the region west of the Mississippi are fresh-water sediments, chiefly the immediate wash of the land, containing fossils which represent not only the fishes and turtles which were their aquatic inhabitants, but the flora and fauna that lived upon their banks.

On the west, however, this lake country was bordered by a chain of volcanoes, which had from time to time their paroxysms of activity,

deluging the lowlands with lava-floods, or discharging into the atmosphere clouds of ashes which, borne far eastward by the prevailing winds, were the agents of more widespread and scarcely less complete devastation. In the end the elevation of the Rocky Mountains, and the erosion of the cañons of the Columbia, Klamath, Sacramento, and Colorado, converted the greater part of the rich Tertiary plain into the only real deserts that now exist on the continent.

Through the center of the region where these great changes were wrought, the belt of the fortieth parallel survey stretches continuously for 750 miles, and yet does not reach near to its eastern border, while it covers but an insignificant portion of its north and south extent. It is evident, therefore, that but a small portion of the records which form the history of the Tertiary ages in Western America come within the limits of Mr. King's survey, but he has made wide excursions both north and south of his special field, and has availed himself of the observations of his co-laborers in Western exploration, so that he has been able to write this history much more fully than had before been attempted.

The following brief summary is all we can give of the most important points in the chapter on the Tertiary rocks, perhaps from its facts and suggestions the most interesting of any in Mr. King's report. During the Eocene four great lakes with different boundaries, and forming different series of sediments, occupied the middle portion of the fortieth parallel belt. These are named by Mr. King: 1. *Ute Lake*, in which the Vermilion Creek beds, 5,000 feet in thickness, accumulated, and which filled the Green River basin to the width of 150 miles, reaching to that distance north of the fortieth parallel, and to a yet unmeasured distance southward; 2. *Gosiute Lake*, from which were deposited the "Green River Beds" of Hayden (the Elko Group of King), 2,000 feet in thickness, which extended westward to the longitude of 116°, and eastward, perhaps, into Middle Park; 3. *Washakie Lake*, in which the Bridger Beds, 2,500 feet thick, were deposited; this occupied the country about Fort Bridger, reaching some 150 miles east and west, and to an unknown distance north and south; 4. *Uintah Lake*, a limited body of water south of the Uintah Mountains, which received the last Eocene sediments, a thin group of clays and sands containing fossils, differing from those of the Bridger Group.

In the Miocene age, the area occupied by the Eocene lakes was mostly dry land, but other lakes not less extensive, and perhaps of equal duration, occupied contemporaneously portions of Nevada and Oregon in the west, and a wide district in the great plains on the east. To the western lake Mr. King gives the name of *Pah-ute*, and its deposits he calls the Truckee Group. The eastern Miocene lake he calls *Sioux Lake*, and its basin contains the strata named by Hayden the White River Group. In the Pliocene a wide extent of the Great Basin was occupied by what Mr. King has named the *Shoshone Lake*, and

its sediments the Humboldt Group. In the middle province was a smaller body of water called the *North Park Lake*, of which the area is underlain by beds to which the same name has been given by Hague and Hayden, while in the region of the Great Plains the Niobrara Group of Marsh was laid down in what King terms the *Cheyenne Lake*.

The details of the description of these Tertiary lakes, and of the history of their formation and disappearance, are among the many things which Mr. King's volume contains, that for want of space must be passed without notice.

QUATERNARY.—One of the most interesting chapters in Mr. King's volume is that which describes the records of the Quaternary age in the region which he surveyed. The salient points in this history are briefly as follows: Along the fortieth parallel in the far West during the glacial period there was no general glaciation, no continental ice-sheet, but glaciers formed on all the more important mountain-ranges, extending down from their summits to the level of from 6,000 to 9,000 feet above the sea. Traces of these ancient glaciers are seen in excavated lake-basins, glaciated valleys, and terminal and lateral moraines. The glaciers of the Uintah Mountains were by far the most important in all this region. Snow and ice crowned the Park and Medicine Bow Ranges, and extended down all the valleys which radiated from them; but the ice-covered area was small as compared with the great breadth of the country. The Uintah Mountains, however, according to Mr. King, then formed a broad-topped table-land 17,000 or 18,000 feet above the sea, all of which was one great ice-field, with local glaciers descending the valleys both toward the north and south. The whole length of the range was thus covered, and the ice-field had a north and south width of some fifty miles. Thus it formed a glacial area considerably larger than that of the Alps at present. West of the Great Basin, as we know from the reports of King and Le Conte, the Sierra Nevada was the theatre of glacial action on a still grander scale.

The topographical changes in the far West during the Quaternary age seem to have been numerous, but not consequent upon great disturbances, although this unquiet region has shown more or less of its instability to the present day. The changes which would most strike an observer were variations in the water-surface; for Mr. King, joining his observations to those of G. K. Gilbert, has shown that even as late as the Quaternary the Great Basin was a well-watered country, and contained two lakes, which in magnitude were scarcely exceeded by any of those now existing on the continent. Of these, one called by Gilbert *Lake Bonneville*, occupied the Great Salt Lake Valley, with a vast extension toward the south and west. Great Salt Lake occupies the deepest portion of its basin, and, with Utah and Sevier Lakes, represents the residue of its water after a long period of dryness, during which the evaporation exceeded the precipitation. The other great Quaternary lake of this region has been named by Mr. King *La Hon-*

tan; it occupied western Nevada with an area nearly equal to that of Lake Bonneville, but more broken with islands and promontories. It is now represented by Pyramid, Carson, and Walker's Lakes.

These two Quaternary lakes were, of course, the products of ages during which the precipitation of moisture in the Great Basin was much larger than now; but Mr. King states that the complete history of the climatic changes in this region during the Quaternary included two moist periods with a dry interval between them, and that these have been succeeded by another interval of aridity, that of the present. Gilbert had previously shown that a period of dryness had preceded the moist period in which Lake Bonneville was filled; and Mr. King's study of Lake La Hontan indicates another period of humidity which preceded that. The reasoning by which he reaches this conclusion is extremely ingenious, and is based upon the varying chemical precipitates from the waters of Lake La Hontan. In past times the waters which drained into this lake were highly charged with carbonate of soda, and during periods when the lake-waters were concentrated by evaporation, Gaylussite, the hydrated double carbonate of lime and soda, was deposited in sheets on its sides. At other times, when the volume of water was greater, the soda was dissolved out, and carbonate of lime alone precipitated in pseudomorphs after Gaylussite. From facts of this character, which we have not space to present in full, he feels warranted in stating—1. That the lake was formed in a period of abundant precipitation, and had free drainage to the ocean; 2. In a period of desiccation, the level of the lake was reduced by evaporation below its outlet, and the saline contents concentrated to the point of formation of Gaylussite; 3. The coming on of a second flood-period which filled the basin to its point of overflow, when the soluble salts were all washed out and the pseudomorph thinolite was formed; 4. A modern rapid desiccation which nearly emptied the lake-basin, leaving only a few small, weakly saline lakes as its representatives. Mr. King connects these periods of greater precipitation with two corresponding periods of glacial extension, and from these facts hints rather than asserts that elsewhere, as well as there, *superabundant moisture* was the cause of glacial extension, and therefore of those records which are generally regarded as proofs of a cold period. A discussion of the phenomena and causes of the "Ice period" would be incompatible with the limitations of this paper, but we may say in passing that the generalization which has been suggested by Mr. King seems hardly warranted by the facts he reports. It is certainly true that there could be no formation of ice or glaciers, however low the temperature, without precipitated moisture, and in many places the extension of glaciers is limited not by temperature, but by lack of moisture; but, to find standards of comparison with the widespread glaciers of the Ice period, we must go to the Arctic and Antarctic Continents. Here we are far removed from the theatre of most active evaporation, and where the

climate is very *cold*, and yet the precipitation is sufficient, with the average temperature, to form continental glaciers of equal dimensions with any indicated by the records of the past, and, so far as we can judge, no other condition is necessary for the extension of the glaciers of Greenland southward to Labrador, the Canadian highlands, and the hills of New England, than a depression of temperature sufficient to congeal and retain the moisture which now flows away nearly as fast as it falls. With the arrest of the flow of the St. Lawrence, for example, and its accumulation year after year as ice and snow, it would not require many centuries to pile the ice as high on the Canadian highlands as it was in the Quaternary age.

In Chapter VI., which forms a *résumé* of the stratigraphical geology, Mr. King refers in his graphic and felicitous way to the conditions of deposition of the 120,000 feet of sedimentary accumulations which form the different groups we have reviewed. The tabular presentation of the stratigraphy (page 544), giving at one view the relations of the 50,000 feet of Archæan, 32,000 feet of Palæozoic, 30,000 feet of Mesozoic, and 15,000 feet of Cenozoic rocks, is the most comprehensive and impressive section which has ever been published, and one that shows at a glance the magnitude of the task which Mr. King has performed in the correlation and coördination of such a vast amount of material.

In the last two chapters of his volume Mr. King discusses at great length the genesis and relations of the Tertiary volcanic rocks, and more briefly the classification of the mountain-ranges and lines of upheaval which traverse his field of exploration. These chapters, though of great interest to the geologist, will perhaps not attract the general reader. We would, however, specially commend them to students of lithology and physical geology, as they contain a vast amount of valuable information on what have been made subjects of special study by Mr. King. There was no part of his duty for which he was better prepared than that he has done here; and perhaps none in which he has acquitted himself more creditably. The most striking generalization which he makes in this part of the book, we are, however, compelled to question. This is a new theory of the origin of vulcanism. Most geologists of the present day believe that the crust of the earth is thicker than was once supposed, and that its thickness is increased by the effect of pressure which holds in coerced rigidity a zone of greater or less depth, which is heated above the point at which it would fuse and flow under the pressure of the atmosphere only, and that local relief of this pressure would permit a greater or less mass of highly heated matter below to burst into fluidity, and perhaps find its way to the surface. Mr. King proposes *erosion* as a sufficient cause for the relief of pressure and the production of volcanic phenomena; but some facts suggest themselves which seem to be incompatible with this theory, viz.: 1. Erosion is so slow—on an average 3,000 years

being required to remove a foot of surface—that solidification by cooling must keep pace with it; 2. Volcanoes are generally not situated in areas of erosion, but along coast-lines and on islands; and, 3. They are conspicuously associated with lines of fracture and elevation.

A simple explanation of the phenomena of vulcanism is suggested by the writer, and that is—the relief of pressure by *slight* arching of the crust of the earth along lines of elevation, while the pressure is maximum under the unbroken areas on either side. This unequal pressure would cause a flow of liquid or viscous matter toward and upward under the mountains that mark the lines of arch and fracture, and would permit heated matter held in solidity by pressure to assume the fluid state.

Mallett's theory, that the arching of plates of the earth's crust, and the arrest of their motion in falling, would generate heat sufficient to liquefy masses of rock, and produce volcanic eruptions, is rejected, for the reasons that the strain on arches of sufficient magnitude would be too great for the resistance of the materials composing them, and as Mr. Fisher argues, the heat generated by this method, even if great enough, would not be localized.

Mallett's theory was framed to account for vulcanism *in the crust of the earth*, on the supposition that the crust was very thick, as claimed by Hopkins, Thompson, and Darwin, but Henessey and Delaunay have clearly shown that the investigations supposed to demonstrate the great thickness of the crust are valueless and irrelevant, as the premises assumed are not those of nature, and that we have as yet no evidence of such thickness of crust as would make it impossible for volcanoes to be fed from a general molten mass below the earth's solid crust.

In conclusion, we take pleasure in commending the numerous maps and plates which embellish these elegant volumes. No other scientific work known to us has so many, nor any more artistic or better adapted to supplement and illustrate the text.

A STUDY IN LOCOMOTION.*

By Professor E. J. MAREY.

IF the interest of a scientific expositor ought to be measured by the importance of the subject, I shall be applauded for my choice. In fact, there are few questions which touch more closely the very existence of man than that of animated motors—those docile helps whose power or speed he uses at his pleasure, which enjoy to some extent his

* "Animated Motors: Experiments in Graphical Physiology." A lecture delivered at the Paris meeting of the French Association, August 29, 1878.

intimacy, and accompany him in his labors and his pleasures. The species of animal whose coöperation we borrow are numerous, and vary according to latitude and climate. But whether we employ the horse, the ass, the camel, or the reindeer, the same problem is always presented: to get from the animal as much work as possible, sparing him, as far as we can, fatigue and suffering. This identity of standpoint will much simplify my task, as it will enable me to confine the study of animated motors to a single species: I have chosen the horse as the most interesting type. Even with this restriction the subject is still very vast, as all know who are occupied with the different questions connected therewith. In studying the *force of traction* of the horse, and the best methods of utilizing it, we encounter all the problems connected with teams and the construction of vehicles. But, on a subject which has engaged the attention of humanity for thousands of years, it seems difficult to find anything new to say.

If in the employment of the horse we consider *its speed* and the means of increasing it, the subject does not appear less exhausted. Since the chariot-races, of which Greek and Roman antiquity were passionately fond, to our modern horse-races, men have never ceased to pursue with a lively interest the problem of rapid locomotion. What tests and comparisons have not been made to discover what race has most speed, what other most bottom, what crossings, what training give reason to expect still more speed?

Lastly, as to what is called the exterior of the horse, and his varied paces, specialists have for long devoted themselves to this department. The horseman is trained to distinguish between these different paces, to correct by the education of the horse those which seem to him defective, to fix by habit those which give to his mount more pleasant reactions or a much greater stability. The artist, in attempting to represent the horse, seeks to transfer his attitudes more and more faithfully, to express better and better the force, the suppleness, and the grace of his motions.

These questions, so complicated, I wish to bring before you by a new method, and I hope to show you that the *graphic method* makes light of difficulties which seem insurmountable, discerns what escapes the most attentive observation; finally, it expresses clearly to the eyes and engraves upon the memory the most complicated notions. The graphic method was almost unknown twenty-five years ago; to-day it is widespread. Thus, in almost all countries, recourse is had to the employment of graphic curves as the best mode of expression to represent clearly the movement of administrative, industrial, and commercial statistics. In all observatories apparatus known as *registering* or *recording*, trace on paper the curves of variation of the thermometer, the barometer, rain, wind, and even atmospheric electricity. Physiology utilizes still more largely recording apparatus; but I shall only require to show you a very small number of these instruments, those

which serve to record forces, rates of speed, or to note the rhythms and the relations of succession of very complicated movements:

1. *Of the Force of Traction of the Horse, and the best Means of utilizing it.*—When a carriage is badly constructed and badly yoked the traveler is jolted, the road is injured, the horse is fatigued more than is necessary, and is often wounded by parts of the harness. Science and industry have long sought to discover these inconveniences, to find out their causes in order to get rid of them. But it is only in our own time that great progress has been made in this respect. When we complain of being jolted in a humble cab, we ought to go back in thought to the time when people knew nothing of the hanging of carriages. No roughness of the road then escaped the traveler. A Roman emperor mounted on his triumphant chariot was, in the midst of his glory, as ill at ease as the peasant in his cart. Except some improvements, such as the use of softer cushions, things went on thus till the invention of steel springs such as are now employed, for the leather braces of old-fashioned carriages still left much to desire.

Does this mean that the present mode of suspending carriages by four and even eight springs is the final step of progress? Certainly not. Our present springs diminish the force of jolts, transform a sudden shock into a long vibration; but the perfect spring ought always to maintain a constant elastic force, to allow wheels and axles all the vibrations which the ground demands of them, without allowing any of these shocks to reach the carriage itself. The search for this ideal spring has engaged the attention of one of our most eminent engineers. M. Marcel Deprez has found happy solutions to the problem of perfect suspension; he will doubtless soon apply these in practice.

A good suspension also saves the carriage by suppressing the shocks which put it out of order and destroy it in a short time. Finally, suspension saves the wheel itself. On this subject let me recall a remarkable experiment of General Morin. On a high-road, in good condition, he drove a diligence with four horses at the trot, and laden with ballast instead of passengers. The springs of the vehicle were raised so that the body rested on the axles. After the diligence had passed and repassed a certain number of times, it was found that the road on which it was running was notably deteriorated. The springs of the carriage were replaced and the same movements were repeated on another part of the road; the marked deterioration was no longer produced. It is thus clearly proved that a good suspension is favorable to a good condition of the road.

But with non-suspended vehicles, in order thus to shock the passengers, disjoint the carriage, and abuse the road, force is necessary. It is the horse which must supply this; so that, independently of the useful work which we demand of them, the animal supplies still other work which gives rise to a multitude of shocks, and has only injurious

effects. The employment of suspending springs has rendered the double service of suppressing injurious vibrations and of collecting into a useful form all the work which they represent.

Is this all? Do there not remain, even with the best carriages, other vibrations and other shocks which must be pursued and destroyed in order to render more perfect the conditions of traction? You have all experienced, at the moment of the sudden start of a carriage, and even at each stroke of the whip on a living horse, horizontal shocks which sometimes throw you to the bottom of the carriage. In a less degree, shocks of the same kind are produced at each instant of traction, for the speed of the horse is far from being uniform, and the traces are subjected to alternate tension and slackness. Here are veritable shocks which use up part of the work of the horse in giving only hurtful effects which bruise and contuse the breast of the animal, injuring his muscles, and, in spite of the padding of the collar, sometimes wounding him. To prove the disadvantages of this kind of shocks, some experiments are necessary. I have borrowed one from Poncelet; it is easily made, and any one may repeat it. I attach a weight of five kilos to the extremity of a small string; taking hold of the free extremity of this, if I gently raise the weight, you see that the cord resists the weight of five kilos and holds it suspended. But if I attempt to raise the same weight more rapidly, I bruise my fingers, the cord breaks, and the weight has not budged. The effort which I have made has been greater than the preceding, since it has exceeded the resistance of the cord; but the duration of this effort has been too short, and, the inertia of the weight not being overcome, all my exertion has been expended in injurious work. If, instead of an inextensible cord, I had attached to the weight a cord a little extensible, the sudden effort of elevation which I made would have been transformed into an action more prolonged, and the weight would have been raised without breaking the cord and bruising my fingers. To render the phenomenon more easy of comprehension, I shall make a new experiment under conditions a little different.

You see on a vertical support (Fig. 1) a sort of balance-beam, which bears on one of its arms a weight of one hundred grammes, on the other a weight of ten grammes suspended at the end of a cord one metre long. Between these two unequal weights the beam is maintained by a spring-catch, which prevents it from falling to the side of the heavier weight, but which, on the other hand, permits the beam to incline in the opposite direction, if we bring to bear on the end of the cord an effort greater than the weight of one hundred grammes. But, by letting the smaller weight fall from a sufficient height, at the moment when this reaches the end of its course, it will stretch the cord which holds it, and will develop what is called a *vis viva*, capable of raising the weight of one hundred grammes to a certain height; but this elevation will only take place on condition that the applica-

tion of this force does not give rise to a shock. If the cord which sustains the weight of one hundred grammes is inextensible, and if that which bears the weight of ten grammes is the same, at the moment of the fall of the latter, you will hear a snap; a shock agitates the whole apparatus, but the weight of one hundred grammes is not raised.

Now suspend this weight of one hundred grammes to an India-rubber cord or an elastic spring, and repeat the experiment. You see, each time that the weight falls, that the hundred-gramme weight is raised to a certain extent. But this elevation is effected under pecu-

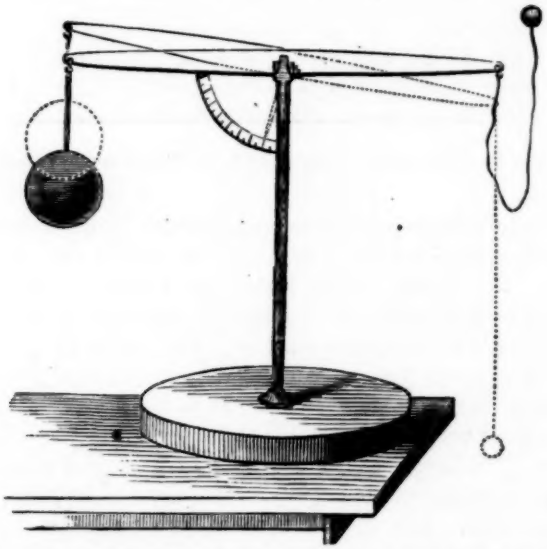

FIG. 1.—Apparatus to show that a *vis viva* directly applied to the displacement of a mass is lost in a shock, while the same force transmitted by an elastic medium may perform work.

liar conditions. At the moment when the weight falls and the cord is stretched, the balance inclines, stretching the elastic spring, but the mass of one hundred grammes does not yet move; it is only when this spring is stretched that the mass, obedient to the prolonged action of this elastic spring, begins to move and rises, representing a certain amount of work accomplished.

Thus the suppression of shock in traction economizes a certain part of the moving labor; it is *then* advantageous to give to the traces of a carriage a certain elasticity. One of the most simple methods consists in interposing between the trace and the carriage an elastic medium. Here are some of these elastic pieces, which I call *tractors*. One of the patterns has been made by M. Tatin; it is composed of a spring which is compressed by traction and deadens the shock. The other is formed of a similar spring placed in the very inside of the carriage-trace.

If you wish to be convinced of the advantage of this mode of traction, yoke yourself to a hand-barrow by means of a rigid leather strap, such as you see used in the streets of Paris or London, where too often man is employed to drag burdens. When you have well noted the painful shocks which this mode of traction transmits to the shoulders, place between the strap and the barrow the elastic tractor and repeat the experiment. After that no doubt is possible; the shoulders are no longer bruised by the shaking of the pavement, and a comfort is experienced which will evidently be experienced in the same degree by a horse placed in conditions of elastic traction.

FIG. 2.—Tracing of the dynamograph for a vehicle drawn by a horse.

To obviate suffering of men and animals is unfortunately not a motive sufficient to induce everybody to modify the old system of harnessing. To certain minds known as *positive*, it is necessary to prove that elastic traction has economical advantages, and that a horse thus harnessed is able to draw heavier loads. This fact, which results from the experiments you have seen, requires to be rigorously proved by the aid of the graphic method. It is to the genius of Poncelet that we owe the record of work expended by different motors.

Everybody knows what a dynamometer is, viz., a spring which, yielding to tractions exerted upon it, is deformed in proportion to the efforts developed. Let us adapt to a spring of this kind a pencil which touches a strip of paper, and let us so arrange things that the movements of the wheel of a carriage shall impress upon the paper a motion of translation. While the effort of traction of the horse will communicate to the spring movements more or less extended, the progress of the carriage will draw out the paper, and from these combined movements will result a curve (Fig. 2), which can be resolved into a series of ordinates or vertical lines in juxtaposition, expressing by their unequal heights the series of efforts resulting from each element of the road traversed. The sum of these elementary efforts, otherwise the surface of paper limited in height by the flexures of the curve, will be the measure of the work expended. If we record in a comparative manner the work done by the same vehicle harnessed with rigid traces or supplied with elastic tractors, we see (Figs. 3 and 4) that the *area* of the curve is greater, that is, that there has been more work expended, while rigid traces have been used. In the most favorable cases that I have met with, the economy of work by elastic traction has been twenty-six per cent.

But, it may be objected, the recording dynamometer itself consti-

tutes an elastic intermediary which suppresses the shocks. But it is not the ordinary dynamometer which I have used in my experiments, but a special dynamometer which undergoes under the strongest tractions only an almost insignificant elongation. This elongation, amplified by certain organs and transmitted to a distance by a lever fitted

FIG. 3.—Tracing of the dynamograph for a vehicle drawn with an elastic intermediary.

with a pen, is recorded in the form of a wavy curve in conditions referred to above. To sum up, in the employment of animated motors for the drawing of burdens, to find out wherever they produce shocks and vibrations, and to absorb them in elastic springs which restore to useful work a force that seemed only to destroy vehicles, tear up the

FIG. 4.—Tracing of the dynamograph for a hand-barrow drawn by a rigid trace.

roads, cause the animals to suffer—such is the direction in which much progress has been realized, and much more may still be realized.

2. *Of the Speed of Animated Motors.*—I shall perhaps astonish many of you by saying that the speed of a vehicle is one of the things most imperfectly known. It is generally believed to be sufficiently expressed by stating how much way has been made and how much time has been occupied for that. I have come, you may say, from the Pont de Sèvres to the Madeleine in 41¼ minutes; the road is well mile-stoned, I possess a good watch; what greater precision do you require? Assuredly you have measured accurately the space traversed and the time employed, but that constitutes only the expression of a mean speed resulting from a series of variable speeds, of accelerations, of retardations, and sometimes of stoppages where time is quite unknown. A rigorous measurement of rates supposes the road traversed by the vehicle at each instant; in other words, the position which it occupies upon the road. It is thus that physicists have determined the accelerated motion of the fall of bodies—Galileo and Atwood, by means of successive measurements, Poncelet and Morin by means of that ad-

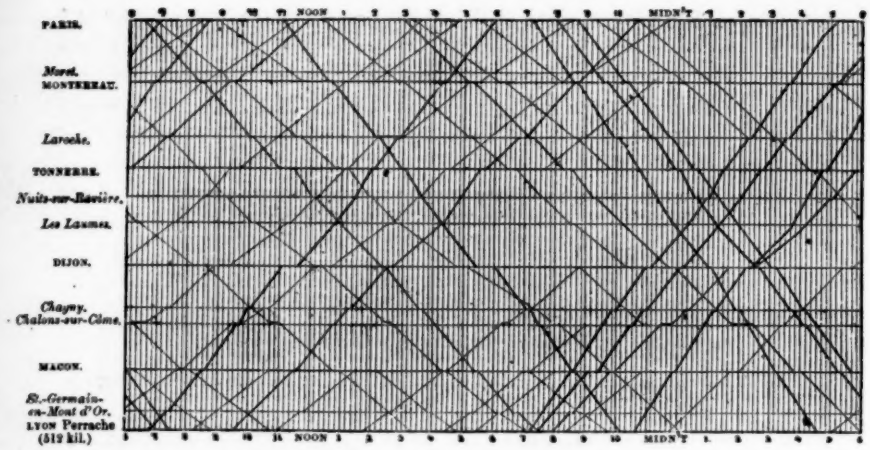

FIG. 5.—GRAPHIC OF THE PROGRESS OF TRAINS UPON A RAILWAY, AFTER IBRY'S METHOD.—When we place the figure before us we read from the left, on the axis of the ordinates, the series of stations, that is, the divisions to be run over; the distance between the stations on the paper is proportional to the kilometric distances which separate them. In the horizontal direction, that is, on the axis of the abscissæ, are counted the divisions of time in hours, themselves subdivided into spaces of ten minutes each. The breadth of the table is such that the twenty-four hours of the day are represented on it, commencing at 6 A. M., and ending next day at the same hour. If we wish to express that a train is on a certain point of the line at a certain hour, we shall point out its position on the table, opposite the station or any point of the line which it occupies, and on the properly chosen division of time. A single point of the table satisfies these conditions. At successive instants the train will occupy points on the table always different; the series of these points will give rise to a line which will be descending and oblique from left to right for trains coming from Paris, while it will be ascending and oblique in the same direction for trains going to Paris. The line which corresponds to each of the trains expresses the hours of departure and arrival, the relative and absolute rates of the trains, the instant of passing each of the stations, and the duration of stoppages. In fact, if we consider any particular train, we see that a train starts from the station at Paris at 11 A. M.; if we follow this train in its progress, we find that it has seven stoppages (during which it is not displaced in space, but only in time). These stoppages are translated by the horizontal direction of the line, opposite the station where they take place; the length of this horizontal line measures the duration of the stoppages. The line of the train, followed to the end, shows that the arrival takes place at 6 P. M.; but, if we reckon the distance on the axis of the ordinates, we see that 512 kilometres have been traversed in eleven hours ten minutes, stoppages included, which gives a mean rate of about forty-six kilometres per hour.

mirable apparatus which traces by a single stroke the curve of a movement.

This machine is now too well known to need description; however, I shall make it work before you in order to interpret its language and to show how a graphic curve translates all the phases of a movement. The parabolic curve traced expresses for each of its points the position in which the body is found at each of the instants of its fall; it thus supplies the most complete information on the nature of the movement. But if, knowing only the space run over and the time employed, we join the two extreme points of departure and arrival by a straight line, that line which will express the mean rate of the fall will not correspond to any of the rates which the body has successively possessed.

The expression of movement by a curve has been put into practice. An engineer named Ibry has devised a method of representing graphically the progress of trains upon a railway. This mode of representation, incomparably more explicit than the tables of figures of our railway *indicators*, has not yet got into the hands of the public; and

this is to be regretted, for it gives a genuine interest to a journey, as you may see by inspection of one of these graphics.

The table which you see (Fig. 5) is prepared by engineers according to the regulation progress of trains, a progress supposed uniform; we see, in fact, that the lines of progress are all straight, joining to each other the two points which express the place and time of departure, the place and time of arrival. It does not then take into account the real movement of the train, which is accelerated or retarded under a great number of influences. The problem which we seek to solve, that of a graphic expression of the real rate of a vehicle, supposes that the carriage itself traces the curve of the roads traversed in function of time. By means of the apparatus which I present to you, and which I call the *odograph* (Fig. 6), a wagon or any kind of carriage traces the curve of its movement with all its variations.

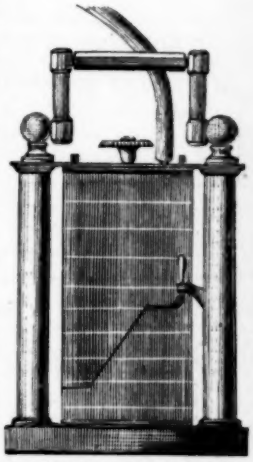

Fig. 6.—Odograph, reduced to one third of its diameter.

This apparatus, based on the same principle as the Poncelet and Morin machine, is composed of a tracing style which moves parallel to the generatrix of a revolving cylinder covered with paper. The movement of the style follows all the phases of that of the carriage, but on a very reduced scale, in order that the tracing of a distance of several myriametres may be contained in the dimensions of a sheet of paper. As to the movement of the cylinder, it is uniform, and commanded by clockwork placed in the interior. In order that the movement of the style may be proportional to that of the vehicle, things have been so arranged that each turn of the wheel causes the style to advance by a small quantity always the same. But as a turn of the wheel always corresponds to the same distance accomplished, the faster the vehicle travels the more turns will the wheel make in a given time, and the more movements of progression will the style undergo. This solidarity between the movements of the wheel and those of the style is obtained by means of a small eccentric placed on the vane. At each turn there is produced a puff of air which, by a transmitting tube, causes a tooth of the wheel of the apparatus to escape, and the style to advance by a small quantity. Similar effects may be obtained by means of electro-magnetic apparatus. Thus the swifter the vehicle goes the more rapidly will the line traced ascend; the comparative slope of various elements of the tracing will express the variations of rate, as seen in Fig. 7.

If we wish to learn the absolute value of time and distance, it is sufficient to know that each minute corresponds to a millimetre counted horizontally on the paper, and that each kilometre corresponds to a

certain number of millimetres traversed by the style in the vertical direction. The course of the style, which corresponds to a kilometre, ought to be experimentally determined for each vehicle, for the perimeter of wheels is not always the same. But it is clear that, if from each kilometre-stone to another we obtain five millimetres, for example, for the course of the style, this length will always be found to be traversed each kilometre by the same vehicle. Our apparatus is then a measurer of distances, and dispenses with the necessity of attending to

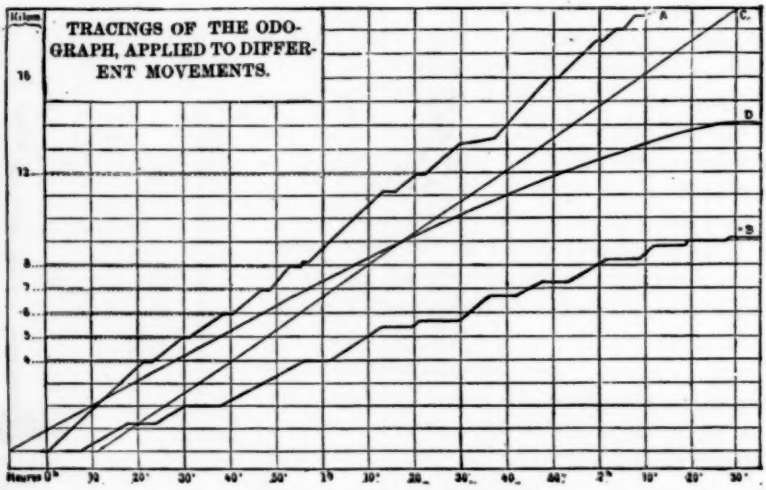

FIG. 7.—TRACINGS OF THE ODOGRAPH: A, rapid coach with stoppages; B, slow coach; C, gas meter, frequency of turns of the wheel; D, curve of the turns of a clock wheel-work with fly.

the existence of kilometre-stones; it enables the distance traversed on any road whatever to be estimated, and even when there is no beaten track. Thus in a journey of discovery we may measure the distance traversed by a cart. To remain in the conditions of ordinary life, have we not sometimes in the country a choice of two or three roads to go from one place to another? To know which is the shortest we appeal to the watch, as if the least duration of a walk corresponded to the least distance. The odograph will give in this respect very precise information.

There are again a great number of questions which we ask daily without being able to solve them. Does such a draught-horse go quicker than such another? Does this trot better to-day than yesterday? By increasing the ration of oats do we increase speed? Compare the slope of two curves of rates, and you will have the reply to all these questions without being obliged to make special experiments on a measured road, watch in hand.

It is not only to the speed of vehicles that the registering apparatus applies; it traces, though with less precision, the rate of progress of

men and animals. We slip into our boots a bellows-sole, which is connected by a tube with a portable odograph. Each pace impresses on the style a small movement, as does each turn of the wheel of a carriage; and, if the paces be absolutely equal, we may measure with certainty the distances traveled. In walking on level ground we take steps of astonishing regularity; but, if the ground rises, the step gains in length; in descents, on the contrary, the steps are shortened. There may result from this slight errors in the distances traversed. Notwithstanding this, the employment of this apparatus will effect a great progress; it may be substituted with many advantages for the pedometer, which gives at the end of a certain time only the paces accomplished, without taking count of the stoppages or the changes of rate.

In short, when we make an experiment on a measured road, if there are produced variations in the length of the tracing represented by a kilometre, we conclude therefrom variations in the length of the pace. Such variations are observed under the influence of the slope of the country, the nature of the soil, the boots we wear, the rate of walking, or the weight carried. These studies in applied physiology have, I believe, a great practical importance, and numerous applications to the march of troops in a campaign.—*Nature.*

JOHN STUART MILL.

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II.

HAVING no more documents until 1830, I propose to make a short critical review of Mill's writings and doings in the interval, upon the basis of the information supplied by himself. I will first endeavor, for the sake of clearness, to extract the chronological sequence of the years from 1820 to 1830, which, from his plan of writing, is not very easy to get hold of.

1821. Returns from France (July). Beginning of psychological studies. Condillac.

1822. Reads the History of the French Revolution; inflamed with the subject. Studies law with Austin. Dumont's Bentham excites him to a pitch of enthusiasm. Locke, Helvetius, Hartley, Berkeley, Hume, Reid, Dugald Stewart, Brown on Cause and Effect, Bentham's Analysis of Natural Religion. Began intimacy with Grote. Charles Austin. First published writings in the "Traveller" newspaper.

1823. Utilitarian Society at Bentham's house: Tooke, Ellis, and Graham. Appointment to India House (May 21st). Letters to the

"Morning Chronicle" on the Richard Carlile prosecution (January and February). Frequent contributions throughout the year to the "Chronicle" and "Traveller." "Westminster Review" projected. Reads up the "Edinburgh Review" for his father's attack upon it in the first number of the "Westminster."

1824. First number of the "Westminster" appears (March). Contributes to the second number on the "Edinburgh Review"; to the third on "Religious Persecution" (?) and "War Expenditure"; to the fourth on "Hume's Misrepresentations in his History."

1825. Principal occupation, editing Bentham's book on Evidence. Starting of "Parliamentary History and Review"; writes the article on the "Catholic Disabilities"; also, on the "Commercial Crisis and Currency" and the "Reciprocity Principle in Commerce." Learned German. Began morning-readings in the Society at Grote's house in Threadneedle Street. Went with some others to the debates of the Owenites' Coöperative Society; founding of the Speculative Debating Society. In the "Westminster," wrote on the "Political Economy of the Quarterly," on the "Law of Libel" (?), and on the "Game Laws" (?) (number for January, 1826).

1826. Utilitarian Society ceases, and readings at Grote's continue. Speculative Society flourishing. Reviews for the "Westminster," Mignet's "French Revolution," and Sismondi's "History of France"; writes two articles on the Corn Laws; replies to the "Quarterly" on "Greek Courts of Justice." Beginning of "mental crisis."

1827. Speculative Society. Readings at Grote's (turned now to Logic). Articles in the "Westminster"; review of Goodwin's "Commonwealth" (?); of Whately's Logic (in number for January, 1828).

1828. Speculative Society. Readings at Grote's, on his father's "Analysis." Last article in "Westminster"—Scott's "Life of Napoleon." Acquaintance with Maurice and Sterling. Read Wordsworth for the first time. (At some later return of his dejection, year not stated, he was oppressed with the problem of philosophical necessity, and found the solution that he afterward expounded in the "Logic.") Is promoted from being a clerk to be assistant examiner in his office.

1829. Withdrew from Speculative Debating Society. Macaulay's attack on "Essay on Government" produces a change in his views of the Logic of Politics.

With regard to these nine years, I will first remark on his articles in the "Westminster Review." He says he contributed thirteen, of which he specifies only three: of the whole, he says generally, they were reviews of books on history and political economy, or discussions on special political topics, as corn laws, game laws, law of libel. I am able to identify the greater number of them.

His first contribution is the article in the second number, on the "Edinburgh Review," which continued the attack made by his father

in the first number; he puts this down as "of little or no value," although to himself a most useful exercise in composition; it is, nevertheless, in respect of his biography, an interesting study. No doubt the opinions are for the most part his father's, though independently and freshly illustrated: the demonstration of the truckling of the "Edinburgh Review" to sentiment and popularity; the onslaught against lubricated phrases; the defectiveness of the current morality as reflected in the "Review"; the denunciation of the pandering to our national egotism: all these were his father *redivivus;* yet we may see the beginnings of his own independent start, more especially in the opinions with regard to women, and the morality of sex.

In the third number (July, 1824) he has an article on "War Expenditure," the review of a pamphlet by William Blake on the recent fluctuations of prices. In the fourth number (October, 1825) he reviews at length a work on English history, by George Brodie, which is especially devoted to Hume's misrepresentations. He enters fully into the exposure of Hume's disingenuous artifices; and at the present time, when Hume's metaphysical reputation is so resplendent, his moral obliquity as an historian must not be glossed over. No doubt his Toryism was his shelter from the odium of his skepticism. Mill says of him: "Hume possessed powers of a very high order; but regard for truth formed no part of his character. He reasoned with surprising acuteness; but the object of his reasonings was not to attain truth, but to show that it was unattainable. His mind, too, was completely enslaved by a taste for literature; not those kinds of literature which teach mankind to know the causes of their happiness and misery, that they may seek the one and avoid the other, but that literature which, without regard for truth or utility, seeks only to excite emotion."

In the fifth number (January, 1825) he assails the "Quarterly" for its review of the Essay on Political Economy in the supplement to the "Encyclopædia Britannica." In the sixth number (October, 1825) there is a long article on the "Law of Libel," the sequel to a previous article on "Religious Prosecutions" (number three), but I have no means of proving them to be his, except that this is one of the topics that he specifies. For the fourth volume, numbers seven and eight, I have no clew. The ninth number (January, 1826) opens with a powerfully written paper on the "Game Laws," which I believe to be his. In the tenth number (April, 1826) there is a short review by him of Mignet's History of the "French Revolution," which is principally occupied with pointing out the merits of the book. I have heard him recommend Mignet as the best for giving the story of the Revolution. He reserves all discussions of the subject; "it being our intention, at no distant period, to treat of that subject at greater length." In the eleventh number (July, 1826) there is a searching discussion of the merits of the Age of Chivalry, on the basis of Sismondi's "History of

France," and Dulaure's "History of Paris"; which is not unlikely to be Mill's. The Corn Laws is one of his subjects, and on this there is an article of thirty pages in the twelfth number (October, 1826). In the following number (January, 1827), there is a second article, referring to Mr. Canning's measure recently brought forward (1826). The concluding article of this number I believe to be Mill's; it deals with a recent article in the "Quarterly," on "Greek Courts of Justice," and is in his happiest vein. It retorts cleverly upon the exaggerations of the "Quarterly," by finding in the English legal practice abuses equal to the worst that the reviewer discovers in the Athenian courts. In the sixteenth number there is a review of Goodwin's "History of the Commonwealth," which seems to follow up the review of Hume.

The article on Whately in January, 1828, was the outcome of the discussions in Grote's house the previous year. It is a landmark not merely in the history of his own mind, but in the history of Logic. His discussion of the utility of Logic, at a time when Syllogism was the body and essence of it, hits the strongest part of the case better than the famous chapter on the "Functions of the Syllogism"; I mean the analyzing of an argument, with a view to isolating the attention on the parts. The discussion of the Predicables is an improvement upon Whately. He even praises, although he does not quite agree with, Whately's attempt to identify Induction with Syllogism, and gives him credit for illustrating, but not for solving, the difficulty of our assenting to general propositions without seeing all that they involve. His view of the *desiderata* of Logic is thus expressed: "A large portion of the philosophy of general Terms still remains undiscovered; the philosophical analysis of Predication, the explanation of what is the immediate object of belief when we assent to a proposition, is yet to be performed; and, though the important assistance rendered by general language, not only in what are termed the exact sciences, but even in the discovery of physical facts, is known and admitted, the nature of the means by which it performs this service is a problem still to a great extent unsolved." On the whole, it can not be said that he had, as yet, made much progress in Logic, even with the assistance of the debates in Threadneedle Street. The real advances apparently remained to be worked out by his own unassisted strength during the next twelve years. I may remark, in conclusion, that I think he greatly overrates the value of Whately's book: "The masterly sketch which he has given of the whole science in the analytical form, previously to entering upon a more detailed exposition of it in the synthetical order, constitutes one of the greatest *merits* of the volume, as an elementary work." If, instead of merits, defects were substituted, the sentence would be, in my judgment, very near the truth. The result of the arrangement was singularly confusing to myself, when I first read the book; and the testimony of all subsequent writers on Logic must be held as against it, for not one, to my knowledge, has ever

repeated it. It grew out of the very laudable desire to approach an abstract subject by a concrete introduction; but the conditions of success in that endeavor have scarcely yet been realized by any one of the many that have made it. At a later period, Grote declaimed strongly against Mill's setting Whately above Hamilton.

The final article in April, 1828, is the review of Scott's "Life of Napoleon." It extends to sixty pages, and is in every way a masterpiece. He had now made a thorough study of the French Revolution, and had formed the design to be himself its historian. He does ample justice to Scott's genius as a narrator, and to a certain amount of impartiality founded on his naturally tolerant disposition, and his aim at winning the good word of everybody. But the exposure of the many and deep-seated defects of the work, both in facts and in reasonings, is complete, and would have marred the fame of any other writer. In point of execution, it is not unworthy to be compared with the Sedgwick and Whewell articles.

I consider some observations called for on the mental crisis of 1826. He had then completed his twentieth year. The subjective description given of his state must be accepted as complete. But the occurrence is treated as purely spiritual or mental; the physical counterpart being wholly omitted; the only expression used, "a dull state of nerves *such as everybody is liable to*," is merely to help out the description on the mental side. Nothing could be more characteristic of the man. There was one thing he never would allow, which was, that work could be pushed to the point of being injurious to either body or mind. That the dejection so feelingly depicted was due to physical causes, and that the chief of these causes was overworking the brain, may I think be certified beyond all reasonable doubt. We know well enough what amount of mental strain the human constitution, when at its very best, has been found to endure; and I am unable to produce an instance of a man going through as much as Mill did before twenty, and yet living a healthy life of seventy years. The account of his labors in the previous year alone, 1825 (a lad of nineteen), is enough to account for all that he underwent in the years immediately following. Moreover, it was too early to have exhausted his whole interest in life, even supposing that he had drawn somewhat exclusively upon the side of activity and reforming zeal. Fifteen or twenty years later was soon enough to readjust his scheme of enjoyment, by delicate choice and variation of stimulants, by the cultivation of poetry and passive susceptibility. It so happened that, on the present occasion, his morbid symptoms were purely subjective; there was no apparent derangement in any bodily organ. Judging, however, from what followed a few years later, we can plainly see in this "mental crisis" the beginning of the maladies that oppressed the second half of his life in a way that could not be mistaken. He got over the attack apparently in two or three years,

with powers of enjoyment considerably impaired. That spirit left him for a time, but returned with another still worse.

Preparatory to the additional elucidation of his life and work from 1830 to 1840, I have constructed the following chronological outline :

1830. Put on paper ideas on "Logical Distinctions among Terms," and the "Import of Propositions." First acquaintance with the French Philosophy of History : St. Simonians ; Comte. Went to Paris after the Revolution of July. Began to write steadily on French politics ("Examiner").

1831. Writing in "Examiner": Essays on "The Spirit of the Age."* Essays on "Unsettled Questions in Political Economy" (1830 and 1831, not published till long after). Resumed "Logical Axioms and Theory of the Syllogism." Tide of the Reform Agitation. First introduction to Mrs. Taylor.

1832. Essays in "Tait's Magazine," and in the "Jurist." Papers on "Corporation and Church Property" and the "Currency Juggle."

1833. "Monthly Repository" : Review of Alison's "History" ; "Thoughts on Poetry" ; Analysis of "Platonic Dialogues." In Paris in autumn, and saw Carrel for the first time.

1834. "London Review" projected ; Molesworth to be proprietor. No special work recorded.

1835. Read De Tocqueville's "Democracy in America." "London Review" : article on Sedgwick.

1836. His father's death. Illness in the head. Three months' leave of absence ; tour in Switzerland and Italy. "London and Westminster Review" : "Civilization" (April). Is promoted to be second assistant in his office (salary £800), and again to be first assistant (£1,200).

* On looking over the file of the "Examiner," to see the drift of these Essays, which I expected to turn upon social questions, more than politics, I find that they all point in the direction of his "Representative Government," in so far as they contain anything constructive. There is a long *exordium* on the character of the present age, as an age of *transition*, with all the consequences growing out of that—unsettlement of existing institutions, in the absence of principles to found new ones upon. "Worldly power must pass from the hands of the stationary part of mankind into those of the progressive part. . . . There must be a moral and social revolution which shall, indeed, take away no men's lives or property, but which shall leave to no man one fraction of unearned distinction or unearned importance. . . . For mankind to change their institutions while their minds are unsettled, without fixed principles, is indeed a fearful thing. But a bad way is often the best to get out of a bad position. Let us place our trust in the future, not in the wisdom of mankind, but in something far surer, the force of circumstances which makes men see that, when it is near at hand, which they could not foresee when at a distance." Discussing the way to secure government by the fittest, he considers the time is gone by when wealth is the criterion. Age has more to say for itself, excepting in a time of transition. He considers at some length the sources of moral influence on society. The last of the series (May 29th) concludes, "I shall resume my subject as early as possible after the passing of the Reform Bill" ; the agitation then going on being used as the climax of the proof that the time is one of transition.

1837. "London and Westminster Review": "Aphorisms" (January); "Armand Carrel" (October).

1838. "London and Westminster Review": "A Prophecy" (January). "Alfred de Vigny" (April). "Bentham" (August).

1839. Illness. Received six months' leave of absence, and traveled in Italy.

1840. "London and Westminster": "Coleridge" (March). "Edinburgh Review": De Tocqueville's "Democracy" (October). With Henry at Falmouth, in his last illness.

He tells us how he was excited by the French Revolution of 1830, and visited Paris in consequence. He wrote on the 13th August a long letter to his father on the state of parties. He begins: "I have had some conversation with M. Say, and a great deal with Adolphe d'Eichthal and Victor Lanjuinais, and I have been a very assiduous reader of all the newspapers since I arrived. At present, if I were to look only at the cowardice and imbecility of the existing generation of public men, with scarcely a single exception, I should expect very little good; but when I consider the spirit and intelligence of the young men and of the people, the immense influence of the journals, and the strength of the public voice, I am encouraged to hope that as there has been an excellent revolution without leaders, leaders will not be required in order to establish a good government." He then goes on to give a detailed account of how the revolution was accomplished —the flinching of the generals of the army, the cowardice and meanness of Dupin above everybody. He has the lowest opinion of the ministry, not a Radical among them except Dupont de l'Eure; all mere place-hunters. Thiers at the meeting for organizing the resistance showed great weakness and pusillanimity. (I heard him long afterward say he detested Thiers.) Of the new measures he praises most the lowering of the age qualification to the Chamber from forty to thirty; he has seen no one that attaches due importance to this change. "I am going to the Chamber of Deputies to-morrow with Mr. Austin, and next week I am to be introduced to the Society of 'Aide-toi,' where I am to be brought in contact with almost all the best of the young men, and there are few besides that I should at all care to be acquainted with. . . . I have heard of an immense number of the most affecting instances of the virtue and good sense of the common people." These last observations are thoroughly characteristic. Young men and *ouvriers* were Mill's hopes.

We learn from himself that he wrote the articles in the "Examiner" on French politics for several years. Even when English politics became all-engrossing, he still maintained his interest and fond hopes in the future of France.

His first bad illness was ten years after the beginning of the period

of dejection in 1826. In 1836, his thirtieth year, he was seized with an obstinate derangement of the brain. Among the external symptoms were involuntary nervous twitchings in the face. Of the inner consciousness corresponding, we have suggestive indications in the family letters of the time. The earliest allusion to his state is contained in his father's first letter to James in India: "John is still in a rather pining way; though, as he does not choose to tell the cause of his pining, he leaves other people to their conjectures." This shows that he had ceased to give his father his confidence in bodily as well as in his mental matters. His medical adviser sent him in the first instance to Brighton. A letter from thence addressed to Henry at home—date not given, but probably near the time of his father's letter—says: "There seems to be a change considerably for the better in my bodily state within the last three days; whether it will last I can not yet tell; nor do I know whether the place has contributed toward it, as the more genial weather of yesterday and to-day is probably the chief cause." He then says that he will continue his stay if the improvement goes on, but is reluctant to be long absent, partly on account of his father's illness, and partly on account of his tutoring "Mary and George." He trusts to Henry to keep him informed on the state of matters, and if he can be of any use to his father he will forego the present advantages and trust to getting well as the summer advances. In a letter, dated 7th May, from Henry to James in India, occurs a further allusion: "There is a new visitor added to the list of young men who come here, a Dr. King, whom John consults about his health" (he afterward married the eldest daughter, but soon left her a widow). John "is certainly ill, but nothing, every one assures us, to be frightening himself about." The father's death occurred soon after (23d June), and on the 29th July Henry wrote: "We are all well in health, except John and myself—John from his old complaint. . . . George and I are going to the Continent with John, who has got leave of absence from the India House for three months on plea of ill-health." In this letter is a postscript: "John has honored me with the present of a watch that was given to my father by Mr. Ricardo; so you see it is trebly valuable to me." This reminds us of John's loss of his own watch; to which I may add that to the end of his life he had only an ordinary silver watch.

Next day, the 30th, the party left London. They traveled in France and Switzerland for a month, and the two boys took up their abode at Lausanne, while John went on to Italy. The expressions as to his state are still (September 4th) very discouraging: "His head is most obstinate; those same disagreeable sensations still, which he has tried so many ways to get rid of, are plaguing him." Three weeks later Henry says: "John wrote to us a very desponding letter, saying that, if he had to go back without getting well, he could not again go to the India House, but must throw it up, and try if a year or two

of leisure would do anything." The same letter incidentally notices that Mrs. Taylor joined the party, and accompanied John in his tour, while the young people remained at Lausanne. We have no further references to this illness; he got round in time, but he retained to the end of his life an almost ceaseless spasmodic twitching over one eye. His renewed capability for work is shown by the dates of his writings immediately subsequent. He had many illnesses afterward, but I do not know that any one was so markedly an affection of the brain as on this occasion.

Two years and a half later, in the beginning of 1839, he went to Italy, and was away six months on sick-leave. The expressions that I shall quote from the correspondence are my only means of knowing the nature and extent of his malady. On January 17th Henry writes: "As to John's health, none of us believe that it is anything very serious; our means of judging are his looks when he was here, and also what we have heard from Dr. Arnott. We are told, however, that his sending him away is because his pains in the chest, which are the symptoms, make it seem that a winter in Italy just now will afford him sensible and permanent benefit for the whole of his life. . . . That this might have turned to gout." The next letter is one from himself, dated Rome, March 11th. He says: "I have returned here after passing about three weeks very pleasantly in Naples, and the country about it. I did not for some time get any better, but I think I am now, though very slowly, improving, ever since I left off animal food, and took to living almost entirely on macaroni. I began this experiment about a fortnight ago, and it seems to succeed better than any of the other experiments I have tried." The remainder of the letter describes Naples and neighborhood—"Pompeii, Baiæ, Pæstum, etc." Ten days later he writes: "As for me I am going on well too—not that my health is at all better; but I have gradually got quite reconciled to the idea of returning in much the same state of health as when I left England; it is by care and regimen that I must hope to get well, and, if I can only avoid getting worse, I shall have no great reason to complain, as hardly anybody continues after my age (thirty-three) to have the same vigorous health they had in early youth. In the mean time it is something to have so good an opportunity of seeing Italy." Again, he writes on May 31st, from Munich on his way home: "I am not at all cured, but I cease to care much about it. I am as fit for all my occupations as I was before, and as capable of bodily exertion as I have been of late years—only I have not quite so good a stomach." He then dilates on the pleasures of his Italian tour, to which he added the Tyrol. He returned to his office-work on July 1st. The only indication of his state is in a letter from Henry: "John is come back looking tolerably well; he is considerably thinner, however." We infer that his primary affection was in the chest, and to this was added

weakness of stomach. In both these organs he was subject to recurring derangements for the rest of his life.*

The "London Review," projected in 1834, started in April, 1835. Sir William Molesworth undertook the whole risk, and Mill was to be editor, although he considered it incompatible with his office to be openly proclaimed in that capacity. His father lent his latest energies to the scheme, and opened the first number with a political article, entitled "The State of the Nation"—a survey of the situation of public affairs in the beginning of 1835, in his usual style. John Mill's first contribution was the Sedgwick article. I have heard that Sedgwick himself confessed that he had been writing about what he did not understand, but my informant was not himself a Cambridge man. Effective as the article was for its main purpose of defending the "Utilitarian Ethics" against a sciolist, it always seemed to me rather weak in the introduction, which consists in putting the question, "For what end do endowed universities exist?" and in answering, "To keep alive philosophy." In his mind, philosophy seemed to mean chiefly advanced views in politics and in ethics; which, of course, came into collision with religious orthodoxy and the received commonplaces of society. Such a view of the functions of a university would not be put forth by any man that had ever resided in a university; and this is not the only occasion when Mill dogmatized on universities in total ignorance of their working.

The second number of the "Review" is chiefly notable for his father's article on "Reform in the Church." It is understood that this article gave a severe shock to the religious public; it was a style of reform that the ordinary churchman could not enter into. The prospects of the "Review" were said to be very much damaged in consequence. John Mill wrote on Samuel Bailey's "Rationale of Political Representation." Bailey's views being in close accordance with his own, he chiefly uses the work as an enforcement of the radical creed. After Bentham and the Mills, no man of their generation was better grounded in logical methods, or more thorough in his method of grappling with political and other questions, than Samuel Bailey.

In the same number Mill reviews Tennyson's poems. He assigns as his inducement that the only influential organs that had as yet noticed them were "Blackwood" and the "Quarterly Review"; on which notices he pronounces a decided and not flattering opinion. He is, accordingly, one of the earliest to mete out justice to Tennyson's powers; and as a critical exercise, as well as a sympathetic appreciation, the article is highly meritorious. In numerous instances besides, Mill was among the first, if not the very first, to welcome a rising genius.

* He took the opportunity of studying Roman history while in Italy; and in Rome itself he read Niebuhr. It was long a design of his to write the philosophy of the rise of the Roman power, but he failed to satisfy himself that he possessed an adequate clew. So late as 1844, or 1845, he was brooding over a review article on this subject.

He closes the number with a political article on the measures of the Government for the session—among others, the Irish Church and the Municipal Corporations bills. His text seems to be that the statesmen of the generation are good in destroying, but bad in construction; and he says that the remark applies to all the Whig reforms, and most of all to Lord Brougham's law reforms.

In the third number (July, 1835) Mill reviewed De Tocqueville's book, which had then appeared—the review extending to forty-five pages. It was a very full account of the book, with copious extracts, but may be considered as superseded by the article written for the "Edinburgh Review" in 1840, which is reprinted in the "Dissertations." The number concludes with a short but energetic review of the Parliamentary session just concluded. It is of the tone and character of all his political writings in those years; a retrospect of recent achievements, with a view of the present position and declaration of the one thing needful for it—a leader. He bitterly complains of the absence of a man of action, and asks: "Why does not Mr. Grote exert himself? There is not a man in Parliament who *could* do so much, or who is more thoroughly the people's friend. . . . O'Connell is the only figure that stands erect." The Liberal press is too much given to truckling to the Ministry. The bull must be taken by the horns; the Tories must be awakened by the apparition of a House of Lords Amendment Bill.

In the fourth number (January, 1836) he had an article entitled "State of Society in America," reviewing a number of books of American travels, and following up the article on De Tocqueville. It is occupied with an attempt to connect the features of American society with the industrial position and political constitution of the country. It may be called one of his minor sociological studies.

The fifth number is the first of the union of the "London" with the old "Westminster," hereafter called "The London and Westminster." It appeared in April, 1836. Mill contributes to it his article on "Civilization," contained in the "Dissertations," and a short political article on the "State of Politics in 1836." I never felt quite satisfied with the article on "Civilization." The definition given at the outset seemed inadequate; and the remainder of the article is principally one of his many attacks on the vicious tendencies of the time. He regards as consequences of our civilization, the decay of individual energy, the weakening of the influence of superior minds, the growth of *charlatanerie*, and the diminished efficacy of public opinion, and insists on some remedies for the evils; winding up with an attack on the universities. To my mind these topics should have been detached from any theory of civilization, or any attempt to extol the past at the cost of the present. The political article is a survey of the measures pending in Parliament. He is very much excited, as his father was, about the spoiling of the country with unnecessary

railways. There is the usual complaint of the torpidity of Radicals, Joseph Hume being his only exception.

For the July number he contributes only the opening article, which is a political survey, on the text of Sir John Walsh's "Contemporary History." It retraces the history of reform and its consequences, and discourses on the relative merits of Tories, Whigs, and Radicals, with the usual complaints. Knowing the state of his health this year, the occurrence of his father's death, and his three months' absence, we are surprised to find that he can contribute to the October number, of which the first article is his, on the "Definition and Method of Political Economy." Doubtless this had been lying by him, and had been brought out to fill a gap.

In January, 1837, the political article is by Sir William Molesworth ("The Terms of Alliance between Radicals and Whigs"). Mill contributes only a short paper on an anonymous work of Arthur Helps, I believe his first publication—"Thoughts in the Cloister and the Crowd." This was another occasion when he displayed his passion for discerning and encouraging the first indications of talent and genius. I remember when I first came to London, this was one of the books he lent me; and we agreed that, in point of thinking power, Helps had not fulfilled the promise of that little work.

For April, 1837, he contributes a review of Fonblanque's "England under Seven Administrations," which would be easy work. The article is laudatory enough, but iterates the author's standing complaint against all the journals, namely, too great subserviency to the Ministry in power. The political summary in the number is again by Molesworth. Carlyle contributes a short paper on the "French Revolution," under an editorial *caveat*.

In July appears the review of Carlyle's "French Revolution," which Mill considers to have been one of his grand strokes in the "Review." Carlyle's reputation was as yet hanging very dubious. The effect to be produced by the "French Revolution" was extremely uncertain. Mill was now well acquainted with Carlyle, and knew how his peculiarities affected people, and how easily a prejudice might be created that would retard his fame for years. A judicious boldness was the only chance, and the article opens thus: "This is not so much a history, as an epic poem; and notwithstanding, or even in consequence of this, the truest of histories. It is the history of the French Revolution, and the poetry of it, both in one; and, on the whole, no work of greater genius, either historical or poetical, has been produced in this country for many years." Nothing could be better calculated to disarm prejudice against the book than the conduct of this article throughout; it is indeed a masterpiece of pleading, and deserved to be successful, as it was. A little later, Mill admitted into the "Review" an article on Carlyle by John Sterling, which was a still more complete exhibition of Carlyle, and is probably yet one of the best

criticisms that he has ever received. Still, when Carlyle, in his "Life of Sterling," refers to that article as the first marked recognition he had received in the press, he was unfairly oblivious to what Mill's article had previously done for him.

In this number the political article has to advert to the death of King William, and the events that followed. The Radicalism is as strong as ever; but the signature (E) is not Mill's, and I do not know the author.

The next number is October, 1837. The opening chapter is the political one, and is by Mill. Its text is the opening of the new Parliament of 1837. It is, if possible, more energetic and outspoken than ever. It addresses first the Ministers, and demands of them the ballot, as a special measure, and a number of other reforms, the Church included. It addresses the Radicals in Parliament in the usual strain. It hits the Tories very hard for their disingenuous dealing on the new Poor Law at the elections, and demonstrates that not they, but the Radicals, were the real upholders of the rights of property. The incitements to action are redoubled, as the power of the Liberals has diminished. I do not know of any compositions that better deserve to be compared with the Philippics of Demosthenes than Mill's political onslaughts in those years.

This number contained also the article on Armand Carrel. The best part of it is, perhaps, the history of French politics from the restoration of the Bourbons, on which he was thoroughly informed. The personality of Carrel is sketched chiefly from Carrel's biographers, to which he adds the impressions made by Carrel on himself. The distinguishing aim of Carrel's political life is remarkable for its common sense and intelligibility—to mitigate the mutual hostility of parties as a preparation for a constitutional *régime*. In the summing up of Carrel's personality Mill displays himself: "Like all persons of fine faculties, *he carried the faculties with him into the smallest things;* and did not disdain to excel, being qualified to do so, in those things which are great only to little men." This doctrine, I conceive, was held by Mill to an erroneous excess; the counter-doctrine of the limitation of the human faculties he never fully allowed for. He believed in *large* minds without any qualification, and saw very little incompatibility between the most opposite gifts.

In January, 1838, appeared the first "Canada and Lord Durham" article. In the "Autobiography" he celebrates the influence exerted by this and his subsequent article on the return of Lord Durham, and believes that they were a turning-point not merely in the settlement of Canada, but in the future of all our British colonies. Besides writing these articles, Mill exercised great personal influence on Lord Durham's Canadian measures, chiefly through his secretary, Charles Buller, who was always very open to Mill's suggestions. The present article apologizes for not reviewing the home political situation at large, be-

cause "a question has arisen which suspends all united action among Radicals. . . . On this most grievous subject we shall, in the course of this article, declare our whole opinion." He yet, however, finds it necessary first to denounce in fitting terms Lord John Russell's declaration of hostility to all reform on the first night of the session. The discussion of the Canadian problem is in his very best style, and is as well worth reading even now as any of his reprinted papers.

The number for April, this year, opens with one of his literary articles, reproduced in the "Dissertations"—"Alfred de Vigny." This article is his latest and most highly elaborated attempt to philosophize upon literature and poetry. The "Thoughts on Poetry" is his only other paper that he has thought worth preserving. The reviews of Tennyson and Carlyle's "French Revolution" are replete with just criticism, but do not reach the height of philosophical explanation. In his philosophy of style, there are many good points, but, as I conceive, some serious omissions. I doubt if he gave enough thought to the subject. The earlier part of the "De Vigny" article on the influence exerted on poetry by political changes, such as the French Revolution, is, I think, very happily expressed, and is quite equal to any other similar dissertations by our best historians and critics. It is when he comes to state the essential quality of the poetic genius or temperament that I think his view defective. In the first place, he puts too much stress on the emotional quality, and too little on the intellectual. In the second place, he is wrong in identifying the poet intellectually with the philosopher or thinker: he regards genius, whether in poetry or in philosophy, as the gift of seeing truths at a greater depth than the world can penetrate. On the former of these two heads he accepts De Vigny's emotional delineation—"the thrill from beauty, grandeur, and harmony, the infinite pity for mankind"—as the tests, or some of the tests, of the poetic nature; but he takes no direct notice of the genius of expression, the constructive or creative faculty, without which emotion will never make a poet, and with which the grandest poetry may be produced on a very slight emotional basis. To criticise Shelley without adducing his purely intellectual force, displayed in endless resources of language, is to place the superstructure of poetry on a false foundation. Shakespeare, in any view of him, was ten parts intellect for one of emotion; and his intellect did not, so far as I am aware, see truths at a greater depth than the world could penetrate. Mill inherited his father's disposition to think Shakespeare overrated; which, to say the least, was unfortunate when he came to theorize on poetry at large.

In August, appeared the review of Bentham, which I will advert to presently.

The next number is December, 1838. It closes with Mill's second article on Canada—"Lord Durham's Return"—vindicating his policy point by point, in a way that only Mill could have done. It concludes:

"If this be failure, failure is but the second degree of success; the first and highest degree may be yet to come."

The succeeding number appears in April, 1839, and contains the last, and in one view the greatest, of Mill's political series. Liberalism in Parliament is now at its lowest ebb: and only some new and grand expedient can be of any avail. Departing from his old vein of criticism of Whigs and Radicals, he plans the "reorganization of the Reform party" by an inquiry into the origin and foundations of the two great parties in the state. He inquires who, by position and circumstances, are *natural* Radicals, and who are natural Tories; who are interested in progress, and who in things as they are. I strongly recommend this article as a piece of admirable political philosophy, and I do not know any reason for his not preserving it, except that it is so closely connected with the passing politics of the time. At all events, it is the farewell to his ten years' political agitation. As this was the year of his second bad illness, I presume the article was written in the end of 1838, in the midst of great suffering.

After six months' interval, the next number appeared October, 1839. It contained no article of Mill's: he had been abroad the first half of the year. The number is otherwise notable for Sterling's article on Carlyle, and Robertson's on Cromwell. In March, 1840, was published the last number under Mill's proprietorship. It opened with his "Coleridge" article.

The Bentham article both stands alone as an appreciation of Bentham's work, and also forms one member of a correlative couple with the disquisition on Coleridge. No one possessed the qualifications of Mill for setting forth Bentham's merits and defects: we wish that he had made still more use of his means in depicting Bentham's personality. But in the mode of dealing with the defective side of Bentham, he undoubtedly gave offense to the Benthamite circle. He admits (in the "Autobiography") that it was too soon to bring forward the faults of Bentham; and, looking at the article now, we may be allowed to say that a little more explanation is wanted on various points; as, for example, Bentham's deficiency in imagination, his omission of high motives in his springs of action, and his aversion to the phrases "good and bad *taste*." It is apparent that Mill is criticising him from a point of view not taken by any other of Bentham's friends and disciples. When we turn to the "Coleridge" article, we find the more explicit statement of his position, as between the great rival schools. There we have a labored introduction to show the necessity of studying the conflicting modes of thought on all questions; we are told that, as partisans of any one side, we see only part of the truth, and must learn from our opponents the other part. Following out this text, Mill endeavors to assign the truth that there is in Conservatism, when purified by Coleridge and raised to a coherent system, or a philosophy. It is needless to advert to the detailed illustration, but the conclusion

is open to remark. A conservative philosophy may be, he says, an absurdity, but it is calculated to drive out still worse absurdities. To cut the matter short, he hopes from it, not the conversion of Conservatives into Liberals, but the adoption of "one liberal opinion after another as a part of Conservatism itself." Surely this is spreading the snare in the sight of the bird. We may ask whether, after forty years' trial, the Conservative philosophy of Coleridge has really borne such fruits; or whether the adoption of Liberal opinions by Conservatives has had anything to do with philosophical consistency. Did Mr. Gladstone's conversion follow, in any degree, from Coleridge's philosophy?

Be this as it may, these two articles made a temporary alienation between Mill and his old associates, and planted in their minds a painful misgiving as to his adherence to their principles or to any principles. There is, in the "Logic," an extract from the "Coleridge" article, on the essential conditions of stability in any society. One of these conditions is, that there be something that is settled, and *not to be called in question.* Grote never ceased to convert this remark into an expression for the standing intolerance of society toward unpopular opinions.

From these two articles it is a natural transition to remark generally upon his principle in conducting the "Review" from first to last. He aimed at a wider comprehension than had ever been allowed before in any periodical representing a sect. He sought out fresh and vigorous thinking, and did not expect a literal adherence to his own opinions. The "Review" abounds in editorial *caveats*, attached to the articles. His principle of seeing partial truth in opposite sides was carried out in this form. He respected real ability when combined with sincerity; and, as an editor, he never refused a reading to an offered contribution; in fact, he delighted in the perusal of young authors' essays.

It was a noble experiment to endeavor to combine opposites and to maintain a perpetual attitude of sympathy with hostile opinions. A dissertation would be well expended in inquiring into its results. For the present, I remark that, as real opposition can not be smoothed down, we must still go on the old track of counter-argumentation; while every honest truth-seeker endeavors to do justice to the case of an opponent. The watchword in these days of the "Review" was, "Sympathize in order to learn." That doctrine, preached by Goethe and echoed by Carlyle, was in everybody's mouth, and had its fling.

Mill's account of the management of the "Review," first as held by Molesworth, and afterward by himself, leaves uncertainties on various interesting points. He was at first sole editor, it appears, without being the avowed editor; he does not say what this exactly meant. In point of fact, he rather supervised than edited the "Review." The

first acting editor, as I am informed, was Mr. Thomas Falconer, a barrister, and now a county court judge, Mill guiding him, but not being the active correspondent with contributors. During Mill's absence in the autumn of 1836, Mr. Falconer did all the editing uncontrolled, and, in the exercise of his editorial discretion, rejected Carlyle's article on Mirabeau, which Mill had previously approved of; the rejection was afterward reversed by Mill, who printed the article in the following January (1837). Although not the impression left by the narrative in the "Autobiography," I am constrained by the facts within my knowledge to believe that Robertson's period as assistant editor must have begun in the summer of 1837; and Molesworth's retirement could not have been till the end of the year. This affects our estimate of the numbers issued at Mill's sole risk. Molesworth may have borne the cost of ten or eleven numbers, which would leave Mill seven or eight, of the eighteen in all. Molesworth expended, no doubt, a considerable sum in starting it; and Mill must have been both very sanguine and also very much bent upon propagating his views in politics, philosophy, and literature, to take the whole risk upon himself. He paid his sub-editor, and also sixteen pounds a sheet to the contributors that took payment. On these eight numbers he must have lost considerably. I can form some estimate of the loss from knowing what Hickson paid to contributors, when he took over the "Review," and worked it on the plan of making it pay its own expenses, he giving his labor gratis.*

* I was well acquainted with Mill's sub-editor, John Robertson, now dead. He was a fellow townsman, and was the medium of my introduction to Mill. I had, for several years, abundant opportunities of conversing with him, and learned a great deal about Mill during our intercourse. But he was very reticent about his own relations with Mill; he never told me, at least, what was his pecuniary allowance as sub-editor; nor did he explain how they worked together in the matter of editing: his habit was to style himself editor, and to seem to take the sole management. He has not left behind him any record of the connection between him and Mill; while I know enough of his history to make me doubt whether it commenced in 1836. Those that knew Robertson were not a little taken aback by Mill's character of him: "A young Scotchman, who had some ability and information, much industry, and an active, scheming head, full of devices for making the 'Review' more salable, etc." I remember on one occasion when Mr. Disraeli, in the House of Commons, quoted Mill as an authority on some economical view, Lord John Russell, in reply, spoke of him as a *learned author*; the next time I met him, he accosted me with his humorous twinkle, "You see what I am now, according to Lord John Russell." The *malapropos* here was not even so bad. Robertson's attainments were of the slenderest description, and his industry very fitful; but he could make a vigorous and brilliant display both in composition and in conversation. He contributed striking articles to the "Review," his best being his "Cromwell." He was also a very good writer of newspaper articles. His impetus and suggestiveness in conversation drew out Mill, who never talked better than he did with him. But although he made friends in London circles and in the clubs, he was very distasteful to many of Mill's associates, and increased the difficulties of carrying on the "Review"; being, in fact, for a *novus homo*, as Henry Mill styled him, somewhat arrogant. He took much interest in the Scotch Non-Intrusion controversy, and coached the Melbourne Government upon the question. About 1844 he disappeared from London, and was afterward rarely heard of. Mill scarcely ever mentioned his name in later years. His widow has gathered together the

Readers of the "Autobiography" remember the account Mill gives of his two most brilliant successes achieved by the "Review"—the saving of Lord Durham, and the rescuing of Carlyle's "French Revolution" from probable failure. In an interesting letter, written soon after the "Review" ceased, he insists with even greater *empressement* on these two feats, but adds, "My *third* success is that I have dinned into people's ears that Guizot is a great thinker and writer, till they are, though slowly, beginning to read him—which I do not believe they would be doing yet, in this country, but for me." His admiration of Guizot persisted some time longer, and led to his most elaborate article of all, in the "Edinburgh Review," five years later; which article he has seen fit to reprint; but we may suppose that Guizot's subsequent career and writings had a disenchanting effect on him as on many others.*

Reverting to the salient idea of his political articles for those seven or eight years—the fatality of there being no leader of the Radical party, although it was composed of very able men—I have often wondered in vain what he expected a leader to do or to be. Everything is not possible even to the greatest of chiefs; and it is doubtful whether any of the men that ever wielded the fierce democracy, from Demosthenes to Gambetta, would have headed a conquering majority in the last years of the Melbourne Ministry. He nearly admits as much, but not without reservation. He says explicitly that his father might have been such a leader; and even implies that he himself could have made the state of matters very different. We may well hesitate on both heads. That his father would have made an able minister or party leader, we must cheerfully allow; but his sentiments and views would have required a thick covering of disguise to allow even his being elected to Parliament, and still more to qualify him for meeting that most pressing want of the time—Reform of the Church.

This paper may fitly conclude with the remaining event of importance in the year 1840—the last illness and death of Mill's favorite brother Henry, which took place at Falmouth, on the 4th of April, in his nineteenth year. He was sent there in the beginning of the year, for the relief of his complaint—consumption; and John plied him with every kindness that he could devise. He went and lived at Falmouth, during his illness, as long as he could get away from his office; and had an opportunity at the same time of seeing a great deal of

extant indications of his career, but he left few or no reminiscences of his more interesting connections.

* I can not identify all the signatures of the articles in the "Review"; but, in addition to the contributors incidentally brought forward in the text, I may mention the names of Lytton Bulwer, Charles Buller, J. A. Roebuck, James Martineau, Harriet Martineau, Blanco White, Andrew Bisset, W. J. Fox, Mazzini, George Fletcher, Henry Cole. Never was so much "good blood" infused into a periodical of the same duration. Of old "Reviews," I think it would be difficult to produce nine volumes possessing the same amount of interest and stimulus.

Sterling, who was there also on account of chest-weakness. A letter of warm acknowledgment to Mr. Barclay Fox, of Falmouth, for the attention bestowed on Henry by his family, is for Mill unusually effusive, and teems with characteristic traits. One not a Christian, addressing a Christian family upon death, and wakening up the chords of our common humanity, is a spectacle worth observing.

A QUESTION OF EATING.

By WILLIAM BROWNING, Ph. B.

IT has long been considered, as by common consent a law of health, that all food should be eaten slowly, not swallowed until well masticated.

Some observations and experiments, however, have been recently made which indicate strongly that this principle of slow eating, so far as health is concerned, is not true with respect to all varieties of food.

Animals in a state of nature, as is generally recognized, tend to accommodate themselves in the most favorable manner to their conditions: if a cow naturally ruminates, why should a dog naturally take a chunk of meat at a swallow without stopping to chew it? It may be said that the ruminant has a special digestive apparatus, but the fact remains that the food is eaten as is best suited to it, and the dog, following nature, does what is best for him, or, in other words, if it disagreed with his digestion to eat rapidly, he would reform, and take it more slowly. Following out this idea, experiments were made upon a dog, with the following results: It the meat, before being fed to the dog, was reduced to a hash, or cut into fine pieces, the digestion was at best imperfect, a considerable portion of the undigested or imperfectly digested meat being found in the excreta. If, under the same conditions, meat was fed to the dog in large pieces, it was bolted at a gulp, with the result that little, if any, passed through undigested; compared with the result from the chopped meat, it could be called a perfect digestion for the coarse form, as compared with a decidedly imperfect digestion for the fine form. So far as simple experiment goes, this must be pretty conclusive for the dog; but can the same hold true with respect to the human subject?

A brief review of the first portion of the digestive process, so far as understood with regard to man, will help in answering this; and first to be considered is the mouth and chewing apparatus. Says Foster: "The chief purpose served by the saliva in digestion is to moisten the food, and so assist in mastication and deglutition. . . . In man, it has a specific solvent action on some of the food-stuffs. On fats it has only a slight emulsifying action, and on proteids none. Its character-

istic property is that of converting starch into grape-sugar."* According to Wundt, "the mouth secretions possess, besides mechanical, chiefly a chemical action—the changing over of the starch and glycogen contained in the food into sugar. The ferment body, which produces this transformation, ptyaline, is not a specific element of the mouth-secretion, since, aside from the intestinal secretions, all tissues and fluids of the body contain starch-ferment."†

From this it will be seen that no digestive action on meat or animal food takes place before reaching the stomach, and that, for vegetable food even, the action of the mouth-secretions is far from all-important.

As to the mechanical action of the mouth in preparing the food for deglutition, this is not specially necessary for morsels of meat of the ordinary size introduced into the mouth, while for a large portion of the vegetable or plant products eaten—and it is upon these that the saliva exerts its chemical action—mastication is necessary before they can be swallowed. The meat-foods are in themselves sufficiently moist, while many dried fruits, breads, and the like, in endless variety, first need thorough reduction.

A piece of jelly the size of a walnut would give little trouble in swallowing, since it is moist and of a yielding character, while few can swallow a pill the size of a pea without distress. Teeth and chewing, then, have their purpose, but, with the exception of the incisors occasionally, that purpose does not include meat unless it has become dried; this is with respect to the food before it reaches the stomach, but, of course, the question then arises, Would it not be in a better condition for digestion if it had been thoroughly masticated?

The food on reaching the stomach is kept in rotary motion by the muscular walls, and only after a time does it begin to pass the pyloric orifice, and then only by degrees, since the digestion farther on is a much finer operation, and can go on but slowly. The length of time that the digestion properly takes, is, according to the present knowledge of the subject, several hours—in fact, somewhat longer than has generally been supposed. Now, if the meat is swallowed fine cut, it begins to pass through very quickly, and before it has been fully acted upon by the gastric juice. This action as regards meats consists in "dissolving the sarcolemma from the muscular fibers, and in dissolving proteid matters and converting them into peptones. . . . On starch, gastric juice has *per se* no effect whatever. . . . On grape-sugar and cane-sugar healthy gastric juice has no effect." In fats alone it has a slight emulsifying effect, but if still in the tissue it is dissolved out. Milk is accordingly acted on by being first curdled on reaching the stomach, after which it is leisurely dissolved again in the desired form.

The rotary movement of the contents of the stomach is to facilitate the action of the gastric juice—to bring the various particles and

* "Text-book of Philosophy," M. Foster, 1877.

† "Lehrbuch der Physiologie des Menschen," W. Wundt, vierte Auflage, 1878.

lumps of the entire mass into contact with it as it exudes from the stomach's walls. If the material has come from the mouth finely ground up, a considerable portion goes over into the duodenum before it has been properly acted upon; but, if it has come down in coarse lumps, these begin shortly to dissolve, passing into a more or less fluid condition, and this can be taken care of with about the same rapidity by the digestive apparatus following: by this arrangement no portion of the food would be allowed to pass from the stomach unprepared for the next step in the digestive process. All portions, then, even the finest fibers, of a meat diet, must be acted upon by the gastric juice before passing on; and this action progresses best by slowly wearing off the outside of the morsels.

Professor Ludwig has made some general experiments as to the truth of this theory upon himself, eating coarsely-cut meat at one time and fine at another, without at least being able to detect any ill effects whatever from morsels as large as it was convenient to swallow.* Many workingmen, business men, and others, almost bolt their food without loss of excellent digestion; we should bear in mind, of course, that they have to chew much of their vegetable food for convenience in swallowing, and also that the indigestion of business men occasionally is due more to their nervous condition at the time.

A slight amount of chewing or mumbling serves to detect harsh substances, as bones, and to prepare for swallowing; foreign matters of considerable size will, however, gradually make their way, and, if not rough, may pass without injury. The writer once had an experience of this nature with a piece of iron an inch in length and a third in diameter.

To conclude, then, with respect to man as well as other flesh-eaters: it is not only not necessary, but also not best, to chew meat of any kind to a fine condition, but to swallow it in convenient morsels; this militates against hash. With regard to all non-meat food, careful mastication is better, but hardly so necessary as has been supposed.

THE CONDITION OF WOMEN FROM A ZOŌLOGICAL POINT OF VIEW.

By W. K. BROOKS.

II.

TURNING now to another part of our subject, and bearing in mind the fact that by far the greater part of the external relations to which our actions are adjusted, and to which it is necessary that they should conform, in order to secure our preservation, safety, and wel-

* Lectures of Professor C. Ludwig (Leipsic), 1878–'79.

fare, are fixed and definite, and have been substantially unchanged for almost, if not quite, the whole period of human development, we see at once that, if the female mind is especially rich in the past experiences of the race, so far as these have resulted in laws of conduct, it follows that, since these experiences have been the same for all members of the race, there must be a greater uniformity in female character than in male character. As this statement is very abstract, I will try to put it in a less general form:

Experience of the order of events has shown that under certain circumstances, of frequent occurrence, certain conduct is proper and conducive to welfare, while its opposite is hurtful.

This experience being constantly repeated, the tendency to do the proper thing when the circumstances occur gradually takes the shape of an instinct, intuition, habit, or law of duty. Henceforward, all persons who have the impulse which has thus been formed will act in the same way when the circumstances arise, but two persons who have not the impulse will follow their individual judgments, and may or may not act alike.

As the female mind is characterized by the possession of these impulses, it is plain that it must be much more easy for one average woman to predict what another average woman will do, or feel, or think, or say in any given case, than for one average man to predict in the same way of another average man.

We may carry this line of thought a little further. Since male minds have the element of originality, male characters differ among themselves; but, since all are members of the same species, fundamental similarity must underlie this individual diversity, and this fundamental similarity must subsist between female and male characters also. The average female character will therefore have more resemblance to two or more male characters than these latter will have to each other, and accordingly, in all cases where relationship or education has not led two men into the same way of looking at things, a woman will be better able than either of them to foresee the conduct of the other under given circumstances, and of course the advantage of a woman over a man in understanding the conduct of a woman will be still greater.

Since on the whole the differences between male characters are slight when compared with their resemblances, and since the points of resemblance are also points of resemblance to women, we should expect that, although the power of women to foresee male conduct is greater than the power of men to foresee female conduct, the superiority is not so marked as in the other three cases. This superiority of women in predicting conduct will be shown by their possession, to a much greater degree than men, of the power to influence or persuade as distinguished from the power to convince or move by arguments; for to convince is to innovate and place matters in a new light, but the

secret of influence is a vivid appreciation of the established motives and incentives to conduct.

The relative power of persuasion of the two sexes, then, may be tabulated as follows:

The power of	To foresee the conduct of or to influence	Is greater than the power of	To foresee the conduct of or to influence
Women	Women	Men	Men
Women	Women	Men	Women
Women	Men	Men	Men
Women	Men	Men	Women

According to our hypothesis, the first line of the table should give the arrangement in which the difference is greatest. In the next line the difference is less; still less in the next; and least of all in the last case. In all cases, however, the superiority of women in this respect should be very marked.

Since our feelings are necessarily much more numerous than our judgments, we should expect to find it much more easy to persuade either a man or a woman than to convince; but, if our theory is correct, the advantage of influence over argument should be much greater when a woman is to be moved than when the effort is directed to a man.

Another difference between the sexes will at once be seen to follow from the above parallel. Since male character has the variable element, and may vary toward either good or bad, it follows that the ideally perfect male character will be more hard to define and more seldom realized than the ideal female character. It is difficult to prove such a statement as this, for the sentiments upon which individual opinion of the subject is based hardly admit of exact statement, but that there is an accepted standard of female excellence, and that the women who realize it are not rare exceptions, can, I think, be shown by the study of female character as depicted by dramatists, novelists, and poets. An appeal to this test is unfavorable to our hypothesis, for characters are selected for novels or poems on account of their originality; but I think that any one who will review Shakespeare, Thackeray, or George Eliot with the subject in mind, and who will compare the more important female characters, will find that they might be transposed from one novel or play to another with much less violence than would attend the transposition of the male characters.

It is hardly necessary to call attention to the obvious fact that our conclusions have a strong leaning to the conservative or old-fashioned view of the subject—to what many will call the "male" view of women. The positions which women already occupy in society and the duties which they perform are, in the main, what they should be if our view is correct; and any attempt to improve the condition of women by ignoring or obliterating the intellectual differences between them

and men must result in disaster to the race, and the obstruction of that progress and improvement which the history of the past shows to be in store for both men and women in the future. So far as human life in this world is concerned there can be no improvement which is not accomplished in accordance with the laws of nature; and, if it is a natural law that the parts which the sexes perform in the natural evolution of the race are complemental to each other, we can not hope to accomplish anything by working in opposition to the natural method. We may, however, do much to hasten advancement by recognizing and working in accordance with this method.

It is no more than just, too, to point out that the peculiar bodily organization and physiological functions of woman have nothing to do with our conclusion. If the perpetuation of the human race were as simple as that of the starfish, where the demands made upon the female organism during reproduction are no greater than those made upon the male, the mind of woman would still be the organ of intellectual heredity, and the mind of man the organ of intellectual variation.

Up to this point I have simply indicated some of the differences between the sexes which the study of the evolution of organisms would lead us to expect. I shall now quote a few extracts from authors whose writings upon the position of women are accepted as valuable contributions to our knowledge of the subject, in order to show that they have recognized the existence of the very differences which we have been led, by theoretical reasoning, to expect.

Mill's essay on "The Subjection of Woman" must be regarded as the most important contribution to the discussion of the relative positions of the sexes as related to future progress; and it is interesting to note that, while he holds that the existing differences are not natural, but are due to the subjection of one sex by the other, he fully recognizes certain profound and characteristic differences, which are precisely in accordance with the present view of their origin and purpose. Mill's evidence as to important differences between the sexes is of the greatest value, both on account of the weight of his opinion in itself, and on account of his being in this case an unwilling witness. He says: "Looking at women as they are known in experience, it may be said of them, with more truth than belongs to most generalizations on the subject, that the general bent of their talents is toward the practical. This statement is conformable to all the public history of women in the present and in the past. It is no less borne out by common and daily experience. Let us consider the special nature of the mental capacities most characteristic of a woman of talent. They are all of a kind which fits them for practice, and makes them tend toward it. What is meant by a woman's capacity of intuitive perception? It means a rapid and correct insight into present facts. It has nothing to do with general principles. Nobody ever perceived a scientific law of

nature by intuition, or arrived at a general rule of duty or prudence by it. These are results of slow and careful collection and comparison of experience; and neither the men nor the women of intuition usually shine in this department, unless, indeed, the experience is such as they can acquire by themselves. . . . To discover general principles belongs to the speculative faculty; to discern and discriminate the particular cases in which they are or are not applicable constitute practical talent; and for this women, as they now are, have a peculiar aptitude." It is only necessary to change two or three words in this last sentence in order to show its complete agreement with the demands of our theory. Its meaning will not be altered by the following reading, which serves to bring out more clearly its implications: To discover general principles belongs to the progressive aspect of the mind, which is most strongly developed in men; to preserve and apply the general principles which are already established belong to the conservative side of the mind, and for this women, as they have been made by the evolution of the race, have and should have a peculiar aptitude. Mill continues as follows: "I admit that there can be no good practice without principles, and that the predominant place which quickness of observation holds among a woman's faculties makes her particularly apt to build over-hasty generalizations upon her own observation, though at the same time no less ready in rectifying these generalizations as her observation takes a wider range. But the corrective to this defect is access to the experience of the human race; general knowledge—exactly the thing which education can best supply."

This sentence, when viewed in connection with our present theory of the relations of the sexes, gives the key to the question of female education—for that form of education which supplies the general knowledge which is so important for the correct application of principles to special cases is culture, as distinguished from the technical training which looks to the discovery of new laws.

The next passage which I shall quote is of the greatest importance, for, founded as Mill's autobiography and numerous passages in his various works tell us it is, upon the personal experience of his life, it contains the germ of the idea which, if fully investigated, might have led him to entirely remodel his essay upon women; the idea that the sexes do not naturally stand in the relation of superior and inferior, nor in that of independent equals, but are the complemental parts of a compound whole. He says: "This gravitation of women's minds to the present, to the real, to actual fact, while in its exclusiveness it is a source of errors, is also a most useful counteractive of the contrary error. The principal and most characteristic aberration of speculative minds, as such, consists precisely in the deficiency of this lively perception and ever-present sense of objective fact. . . . Hardly anything can be of greater value to a man of theory and speculation, who employs himself, not in collecting materials of knowledge by observation,

but in working them up by processes of thought into comprehensive truths of science and laws of conduct, than to carry on his speculations in the companionship, and under the criticism, of a really superior woman. There is nothing comparable to it for keeping his thoughts within the limits of real things, and the actual facts of nature. Women's thoughts are thus as useful in giving reality to those of thinking men as men's thoughts in giving width and largeness to those of women." Here we have a clear recognition of the law that width and largeness, mental growth, originate in the male, and are then preserved by women, and the context leaves no room to doubt that the "really superior woman" which filled the author's memory at the time this passage was written, was a woman in whom this feminine characteristic was well developed; that she was a woman filled with the fruits of human experience; and it is a little strange that he fails to see that the relation with which, for a man of speculation, there is nothing comparable, may have a wider value, and be of the greatest importance to humanity as a whole.

The next passage which I shall quote is still more to the point. He says: "Let us now consider another of the admitted superiorities of clever women, greater quickness of apprehension. Is this not preeminently a quality which fits a person for practice? In action everything depends upon deciding promptly. In speculation nothing does. A mere thinker can wait, can take time to consider, can collect additional evidence; he is not obliged to complete his philosophy at once lest the opportunity should go by. The power of drawing the best conclusion possible from insufficient data is not, indeed, useless in philosophy; the construction of a provisional hypothesis consistent with all known facts is often the needful basis for further inquiry. But this faculty is rather serviceable in philosophy than the main qualification for it; and for the auxiliary as well as for the main question the philosopher can allow himself any time he pleases. He is in no need of doing rapidly what he does; what he rather needs is patience to work on slowly until imperfect lights have become perfect, and a conjecture has ripened into a theorem. For those, on the contrary, whose business is with the fugitive and perishable—with individual facts, not kinds of facts—rapidity of thought is a qualification next only in importance to the power of thought itself. He who has not his faculties under immediate command in the contingencies of action might as well not have them at all. He may be fit to criticise, but he is not fit to act. Now it is in this that women, and the men who are most like women, confessedly excel. The other sort of man, however preëminent may be his faculties, arrives slowly at complete command of them; rapidity of judgment and promptitude of judicious action, even in the things he knows best, are the gradual and late result of strenuous effort grown into habit."

I have quoted these passages from Mill at length, as they give a

very clear although somewhat narrow statement, by the strongest advocate of the fundamental likeness of the sexes, of what I take to be the most important psychological difference between them.

According to Mill—and I think that universal experience will justify his view—the highest type of woman is distinguished by her power of intuition, by her concrete acquaintance with the laws and principles which have been established by experience and generalization, by a constitutional knowledge of these laws which amounts to habit, so that she is able to recognize in actual practical life the action which is proper in any given case, without the necessity for a slow process of comparison and thought; by that immediate command of the faculties which is necessary for action.

This power of correctly and promptly applying the established scientific laws, which are the result of all the experience of the past, to the actions of ordinary practical life, is common sense, as distinguished from originality.

The highest type of male intelligence, on the other hand, is distinguished by the power to abstract and compare, and by a slow process of thought to reach new generalizations and laws, and to see these in their abstract and ideal form, freed from all the complications of their concrete manifestations. To this power is often joined a woful and disastrous lack of common sense, or power of prompt and proper decision and action in special cases.

Lecky, in his "History of European Morals," gives an excellent summary of the most marked differences between the male mind and the female; and, although we do not agree with him in thinking that a departure from the male type is in all cases to be regarded as an inferiority, we can not fail to note how exactly his account agrees with the demands of our hypothesis.

He says: "Intellectually a certain inferiority of the female sex can hardly be denied when we remember how almost exclusively the foremost places in every department of science, literature, and art have been occupied by men; how infinitesimally small is the number of women who have shown in any form the very highest order of genius; how many of the greatest men have achieved their greatness in defiance of the most adverse circumstances, and how completely women have failed in obtaining the first position, even in music and painting, for the cultivation of which their circumstances would appear most propitious. It is as impossible to find a female Raphael or a female Händel as a female Shakespeare or a female Newton. Women are intellectually more desultory and volatile than men; they are more occupied with practical instances than with general principles; they judge rather by intuitive perception than by deliberate reasoning or past experience. They are, however, usually superior to men in nimbleness and rapidity of thought, and in the gift of tact, the power of seizing rapidly and faithfully the finer impulses of feeling, and they have therefore often

attained very great eminence as conversationalists, as actresses, and as novelists. In the ethics of intellect they are decidedly inferior. Women very rarely love truth, though they love passionately what they call 'the truth,' or opinions they have received from others. They are little capable of impartiality or of doubt; their thinking is chiefly a mode of feeling; though very generous in their acts they are rarely generous in their opinions, and their leaning is naturally to the side of restriction. They persuade rather than convince, and value belief rather as a source of consolation than as a faithful expression of the reality of things. They are less capable than men of distinguishing the personal character of an opponent from the opinions he maintains. Their affections are concentrated rather on leaders than on causes, and if they care for a great cause it is generally because it is represented by a great man, or connected with some one whom they love. In politics their enthusiasm is more naturally loyalty than patriotism. In benevolence they excel in charity rather than in philanthropy." While I can not believe that Lecky's statement is entirely unprejudiced, I think no one will deny that the views which I have quoted agree in the main with those which have gained general acceptance in the past. At the present time, however, there is a growing tendency to regard the relations of the sexes as due in great part to male selfishness; and while the substantial correctness of our view of the differences between the male and the female character is acknowledged, its origin is attributed to the "subjection" of women by men. In this paper I have attempted to present reasons, which I believe are new, for regarding the differences as natural and of the greatest importance to the race.

Those who acknowledge the weight of my argument, as applied to evolution in the past, may, however, question its applicability to the human evolution of the future. It may fairly be urged that while we grant that the course of evolution from the lower forms of life up to rational man has been by the slow process of variation and heredity, we have now passed into a new order of things, and the great advances of the human race have been and are now brought about by the much more rapid and totally dissimilar process of intelligent education. It may be urged that heredity does very little more for the civilized than for the savage child, and that the wide difference between the savage and the civilized adult is mainly the result of the training and instruction of the individual; that it has not been brought about by the destruction of those children whose congenital share in the results of the intellectual advancement of the race is most scanty. It may be urged that, since man has reached a point where progress is almost entirely intellectual, and depends upon his own efforts, he is free from the laws by which development up to that point was reached.

We are not concerned at present with the question how far progress might be accelerated by intelligent selection, and we may therefore conditionally accept the view that future progress, for some time

to come at any rate, must depend almost entirely upon education; but, far from holding that this conclusion will allow us to ignore or obliterate the differences between the male and the female intellect, I believe that the full significance of these differences can be appreciated only in their relation to higher education. The scope of the present paper will only allow the space for an outline sketch of the reasons for this belief. As the field of human knowledge widens in all directions, as society becomes more complex, and as the points of contact between man and his inorganic environment multiply, the amount of general education which each individual must receive before he is in a position to hold his own, and to guide himself rationally in all the emergencies of life, and to enjoy his share of the benefits which our intellectual advancement has placed within his reach, increases in a geometrical progression, and the amount of time demanded for general liberal education increases in the same ratio. Meanwhile the amount of special preliminary training which must be undergone in order to fit a person for new and original work in any department of knowledge or art increases at the same rate, and makes greater and greater inroads upon the time which is needed for general education. At present the most important, delicate, and complicated of educational problems, the problem which each individual must meet and decide upon, and the problem which engrosses most of the thought of educational bodies, is where to draw the line between general culture and practical or technical training.

Culture in its widest sense is, I take it, thorough acquaintance with all the old and new results of intellectual activity in all departments of knowledge, so far as they conduce to welfare, to correct living, and to rational conduct; that is, culture is to the intellectual man what heredity has been to the physical man. Culture is concerned only with results, not with demonstrations, and does not look to new advances; while technical training is concerned with methods and proofs, and values the results of the methods and investigations of the past only as they contribute to new advances. Technical training looks to progress in some one definite line, one radius of the growing circle of the domain of human intelligence, and ignores the rest of the circumference. It is to the intellectual man what variation is to the physical man. By culture we hold our own, and by technical training we advance to higher levels. Both are equally important to human welfare, and the great problem of the future is how to secure each to the greatest degree without sacrificing the other. The analogy of the rest of the organic world would seem to indicate that this is to be accomplished by "division of labor." If the female mind has gained during its evolution an especial aptness for acquiring and applying the results of past progress, by an empirical method and without the necessity for studying proofs and reasons, it would seem especially fitted for culture, as distinct from training, while the

male mind is best fitted for education by that process of inductive training by demonstration and experiment which leads to new advances. The methods employed in the general instruction of young men and young women should not therefore be identical. With the one the field may be very wide and the methods empirical, and with the other the range more narrow and the methods more strictly logical. In this way each type of mind will be developed in the manner for which it has an especial fitness; and we have the strongest grounds for the belief that this method would also gradually result in the extension of that congenital acquaintance with nature which is the common stock of the race, and would thus leave more time for the special training of those minds which are by nature best fitted to receive it. It is unavoidable that a bald outline of a view which has such wide implications should afford many openings for serious criticism; but the present article does not admit of the expansion of the idea, even if its detailed examination could be fairly included in the province of biology. Having traced the origin and significance of sex from its lowest manifestations to a point where it becomes purely intellectual, the biologist may fairly leave the subject in the hands of the psychologist.

A VISIT TO THE NEW ZEALAND GEYSERS.

By CLEMENT BUNBURY.

THE Geyser district of New Zealand is, at some future day, to be the great sanatorium of the southern world; meanwhile, it is so little known that some account of a visit lately made to it may not be uninteresting.

While "globe-trotting" with a friend, we found ourselves in April last year at Auckland, New Zealand, and were kindly invited by the Governor to join him in a visit he was going to make, with the Commodore and a large party, to the geysers.

The party assembled at Tauranga, a port about a hundred and forty miles southeast of Auckland, and the most convenient starting-point for Ohinemutu, the headquarters of the hot-lake country. The little town was gay with flags and triumphal arches, and crowded with Maories looking forward to a big drink in return for the dance with which they received the Governor. I was disappointed to find the natives were broad-nosed, thick-lipped, tattooed savages, or at least so they appeared at first sight. The men are decidedly superior in appearance to the women, and among the young people tattooing is becoming unfashionable.

From Tauranga to Ohinemutu is about forty miles over a good road, except through what is called "the eighteen-mile bush," where

the road possesses all the ills to which a bush-road is heir. About three miles from Tauranga the road passes through the celebrated Gate Pah, where English soldiers in a panic ran away from the Maories, and left their officers to be killed. The Pah is well placed on the top of a ridge looking out over Tauranga and the sea. Almost all traces of the earthworks have now disappeared, and the cluster of gravestones in the neglected little cemetery at Tauranga will soon be the only remaining evidence of that disastrous day. About eight miles beyond the Pah we had our first experience of a New Zealand bush. It was magnificent. I can not say the same of the road. A great part of it is what is called "corduroy road," that is, trunks of trees, about eight or nine inches in diameter, were laid close together across the track, forming a kind of loose bridge over the soft places. Some of the trees, especially the rimu, a species of yew, here called a pine, were of immense size and age; in places tangled masses of red flowering creepers completely hid the trees. The tree ferns were the perfection of lightness and beauty, the dark-leaved shrubs setting them off to great advantage.

At Ohinemutu we found two small hotels; the charges were very moderate, and the attention paid to visitors is all that can be desired. The land here still belongs to the Maories, who refuse either to sell it or let it; and the hotel-keepers, who are only tenants-at-will, are naturally unwilling to spend much money in building with such an insecure tenure. One creek of Lake Rotorua, on the banks of which Ohinemutu stands, is filled with boiling springs, which heat the waters of the lake for a considerable distance. This creek is a favorite bathing-place, but, as it is dangerous in the dark, my friend and I tried a natural bath, which has been inclosed by the hotel-keeper to keep out the natives. It was as hot as we could bear it, very soft, buoyant, and bubbling, and after our long, bumpy drive, perfectly delicious. When we had got thoroughly warmed through, I thought lying in the soft bubbling water the most perfect sensuous pleasure I ever experienced.

The next morning we visited the many boiling-water and mud springs in the immediate neighborhood of the village. On a small peninsula, between our hotel and the lake, there are a great many native dwellings, called *whares* (pronounced *warries*). A whole tribe formerly lived there, but one night the end of the peninsula suddenly collapsed and disappeared in the lake, destroying, of course, all its inhabitants. There is, in the midst of the village, a large native building called the "Carved House"; its sides are covered, inside and out, with intricate carving, chiefly of grotesque human figures. By Maori law, the carved figures may only have three fingers on each hand, lest any evil-disposed persons should mistake them for caricatures of their ancestors. This native settlement owes its existence to the many hot springs with which the peninsula abounds, the boiling water standing

to the natives in the place of fire, and saving them an infinity of trouble with their cooking and washing arrangements. One desirable result of the abundance of warm baths is the undoubted cleanliness of the people.

About a mile farther along the banks of the lake, we came to what is called the Sulphur Point. It certainly deserved its name. The surface of the ground is literally honeycombed with pools of boiling water and mud-holes, impregnated with sulphur or alum. The smell was perfectly fearful. One mud-bath that we ventured into certainly did not look tempting; great waves of thick brown mud bubbled up in the middle of the pool, and rolled lazily toward its sides. It was just a pleasant temperature, very smooth and oily, and, notwithstanding its appearance, decidedly a success. We next tried a pool of thinner mud, and ended with a swim in the cold waters of the lake, feeling all the better for our strange experience. All the pools have been given stupid English names by the hotel-keeper; the one we first bathed in is known as "Painkiller," and enjoys a high reputation for curing rheumatism. It was here that a young Englishman lately nearly lost his life. A large bubble burst near his face, the poisonous gases from which rendered him insensible; and had it not been for a Maori, who happened to be standing near, he must infallibly have been drowned. The whole neighborhood is a dangerous one; the crust of the earth is in many places so thin that one may at any moment find one's self standing in boiling water. The guides take so much pleasure in recounting all the accidents that have happened, that I felt I should be conferring a personal favor on them if I fell in, and was boiled sufficiently to be worth talking about in the future. The surface of the ground is in places covered with masses of pure sulphur. We lighted it in places, and it began to burn freely, and may be burning still for all I know to the contrary.

In the afternoon we saw, for the first time, a body of water thrown any considerable height into the air. It was at a place called Whakarewa-rewa, about two miles from the hotel, amid the finest hot springs of the Rotorua district. The geyser had been dormant since 1869 until this particular week, and each day it seemed to gather strength and volume. The mighty fountain has formed for itself a fine circular base, about thirty feet high, of silica, roughly resembling white marble. After being quiescent for a few minutes, the water began to leap up through the circular cavity at the top of the cone, and, rising higher and higher at each leap, at last culminated in splendid volumes of clear bright boiling water, thrown fully forty feet into the air. Dense masses of steam floated from the water in mid-air, but the column of water itself fell so nearly perpendicularly that we were able to stand as near to it as the intense heat would permit. After playing for about five minutes, the fountain gradually subsided, to take a rest, lasting about eleven minutes, before its next display. The geysers

are curiously intermittent in character, and according to all accounts are, on the whole, less active than formerly.

Two of the baths here deserve mention. One called the oil-bath has water so oily as hardly to adhere to the skin enough to make a towel necessary on coming out; the other is a very warm creek opening out into a fast-flowing river of cold water, and affording the most delightful gradations of temperature between the two. All the pools have their distinctive character: some are very active, others sullen; some pretty, bubbling, shallow basins, others dark deep blue of endless depth; some bright and clear as crystal, others milky, or of mud of various consistency; some blowing off steam like fifty steam-engines, and many, alas! very many, smelling beyond the power of words to describe. It is curious how quickly one gets accustomed to the ceaseless sound of boiling water, or the dull, soughing sound of boiling mud that one hears on all sides, often without being able to see the hole whence it comes.

In the evening the natives treated us to a *haka*, or dance, in honor of the Governor. It took place in the carved house I have already spoken of, the weird, grotesque carvings of which added to the strangeness of the scene. There were about a hundred dancers ranged in five rows, the front one consisting of about twenty young women gorgeously apparelled in tight-fitting red or white calico bodices, and flaming-colored rugs worn like kilts. When the Governor entered they greeted him with the most awful noise, shouting, yelling, laughing, and in some diabolical way imitating the noise of the beating of tin cans, the barking of dogs, and rapid hand-clapping. From one or two of the specimens that were translated to us, it was as well, perhaps, that their shouts of welcome were expressed in Maori language. The young women certainly seemed to enjoy, and to make the most of, the opportunity for saying naughty things. The dance lasted about an hour; it was curious, and as a novelty amusing, but rather monotonous. There was but little movement of their feet; it consisted chiefly of swaying their bodies and arms about, going down on their knees, imitating rowing and gathering crops, slapping their own legs and then their neighbors'. The men then took the place of the women, and went through very similar performances. The whole dance was accompanied by a noise that would have put pandemonium to shame; it sounded like a mixture of beating of trays, dogs fighting, gigantic snoring, and a very full, deep bass rumbling in the throat. At times there seemed to be a kind of rhythmic song, interspersed with yells and short, sharp cries of "Hue, hue!" "Ha, ha!" "Pakeka!" The young women winked and grinned and twisted about beyond what was strictly correct; but they seemed to enjoy the really hard work of the dance most thoroughly. There was always a chief running up and down, dancing, and declaiming in the foreground, bidding defiance to all the world apparently, but in reality, I believe,

merely suggesting that he would like to drink his Excellency's health. Far the most comical feature of the dance was a naked little imp who stood in front of the first row, exactly opposite the Governor, and imitated playing the fiddle with his little thin arms, all the while thrusting out his tongue, rolling his eyes nearly out of his head, and making the most fearful faces and contortions. A little girl who tried to do the same had not nearly the same real genius for making herself hideous and grotesque. At last a liberal supply of beer was promised them; the dance came to an end, and the Governor departed amid an uproar if possible more awful than before. The natives were very well-grown, friendly, and cheery, with a perfectly childish delight in making a noise. Their noses are too wide and their mouths too big for them to be good-looking; but, with large bright eyes and white teeth, many of them are very pleasant-looking.

Later in the evening two chiefs of another tribe sought an interview with the Governor to invite him to visit Wairoa, the village nearest to Rotomahana, the gem of the hot-lake country. They were very jealous that he should visit Rotorua and not pay them a visit. I never knew two men less willing to take "No" for an answer, or much readier in meeting all objections; but the Governor was obdurate, and they had to be content with the Commodore, whom they called "the king of the sea," and apparently regarded as very small beer compared to "the king of the land." One of the chiefs was called Major Kemp, having been given the title for services rendered to us during the last Maori war. He was an intelligent, courteous man, of splendid *physique*, certainly over six feet high, and strong and active as a tiger.

Next morning we rode over to Major Kemp's village of Wairoa with the Commodore, Mr. F—— (the member of the Ministry in attendance on the Governor), and Captain Mair, the resident magistrate, who, from his knowledge of the country and language, proved himself an invaluable cicerone. On our way we passed through a lovely piece of bush, in which we found a specimen of the curious natural phenomenon "the vegetable caterpillar." It appears that the caterpillar, when it buries itself in the ground preparatory to changing into a chrysalis, is attacked by a fungus, which kills it, and sends out one or two shoots, something like the seed-bearing fronds of some ferns, several inches in length, from the head of the unfortunate caterpillar. Farther south we came across a tract of bush where they are by no means uncommon. The caterpillar is a large one, and, as far as I could judge, of the goat-moth species. At Wairoa we presented some gaudy-colored rugs to Major Kemp's wife and one or two other important ladies. They gathered together by the roadside trying on their new things, inside and out, and seeming immensely pleased with their finery. We visited a pretty waterfall and cascade, and then embarked in a boat, rowed by four stout young Maories, to cross Lake Tarawera. The lake is very beautiful; the shores are well wooded, in many places

coming sheer down steep and rocky several hundred feet into the water, and backed by fine mountains. At the end of the lake a stream of warm water runs into it from the Lake Rotomahana, but the stream is so swift that progress against it is very slow; we therefore left the natives to bring the boat up, while we walked on with one of them for a guide. A walk of about a mile brought us to the top of some high ground, whence we got our first view of the glorious white terrace of Rotomahana.

It was a sight that never can be forgotten. It is impossible to imagine anything more lovely than the appearance of that marvelous marble-looking terrace, lying, set in a green frame, on the mountain-side, and reflected again in the glassy water of the lake, as we first saw it in the rosy light of a calm autumn sunset. To get to the terrace we had to cross the warm stream; the boat had not yet appeared, and we were impatient. After a slight hesitation, the guide thought he could carry us across. The stream was deep and swift, but the man took us all safely over without a single false step; only when it came to Mr. F——'s turn, the Maori wanted to have a little preliminary practice with him on dry land first, Mr. F—— being about three times as big as his porter. Captain Mair then took us under his charge to explore the wonders of the white terrace.

The general appearance of the terrace is that of a gigantic staircase on the mountain-side. It is about one hundred and fifty feet in height, and at the top nearly three hundred feet across, and fully twice as much round the lowest steps. The steps are roughly semicircular in form, varying from two or three to ten feet in height, more or less smooth on their horizontal, but on their perpendicular faces carved by the trickling water into the most delicate representations of flower and fruit carvings, or soft, white, coral sprays. At the top there is an immense caldron of pale-blue boiling water of unknown depth; even the steam rising from it in clouds was quite decidedly blue. This caldron in all probability is the crater of an extinct volcano which has been invaded by water. The idea that the origin of the terrace is due to volcanic agency, and not to deposits by the water, is supported by the fact that where the silica crust has been knocked away a formation of coarse tufa and pumice-stone appears. The depositing power of the water is, however, very great, and articles exposed for curiosity to its action become very quickly covered with a delicate white coating. On each step there are holes of various sizes filled with the most lovely blue water, slightly milky, of the most perfect turquoise-blue, looking, oh! so beautiful in its coral cups. The water from the caldron pours down, steaming and bubbling, overflowing from hole to hole, losing its heat by degrees on the way, until it reaches the lowest steps quite cold. These lowest steps were especially beautiful; the pools on them were larger and bluer than on the others, and the absence of steam left them in perfect peaceful beauty; the steps, too, though generally of a purer

white than the upper ones, had in places large black markings on them that brought out to great advantage the contrast between their delicate pale-blue water and that of the dark-colored lake that lay at their feet.

We camped for the night close by the terrace, cooking all our provisions in one of the natural boiling springs. During the night an ill-natured rat jumped into our spring, and compelled us to seek another cooking-place for breakfast. While the Commodore and I were lying in a warm pool, smoking a last cigar before going to bed, Mr. F—— proposed to join us; we warned him that the pool was very shallow, but he was not to be dissuaded. When the moon shone out from behind a cloud it revealed, as we expected, a round white island in the middle of our bath. After trying in vain to make waves big enough to cover our newly-discovered island, we induced Mr. F—— to roll over; the result was very comical, but it could hardly be said to be an improvement. We found it no easy matter to get to sleep; the ground was very hot, and every now and then jets of hot steam would find their way through the thin earth-crust and parboil us and soak our blankets. All night there was the sound in our ears of boiling water, so that it was difficult to get rid of a feeling of insecurity natural to so uncanny a sleeping-place.

We began the next day with an early bath in the basins on the white terrace, beginning with the hottest we could bear, and working our way down to the cold water: mortal man surely never had a more magnificent bath-room. After breakfast we crossed the lake in canoes to the pink terrace. It is not so large as the white, but of smoother and more regular form; none of the steps are more than six feet high, so that the baths in them are all shallow, but the steps, covered with a bright salmon-pink incrustation, run more evenly right across the terrace. Some of our party, who had visited the terrace two days before, had, I am sorry to say, written their names in pencil on the smooth pink steps. The warm water, instead of washing them away, had even in so short a time covered them with a transparent film of silica, and there they will remain, along with the names of hundreds of other cockney-souled tourists, enshrined for ever. The water here is perfectly clear, and of a much deeper blue than at the other terrace; that at the top is of a splendid bright deep blue, but the steam is very white. The setting of the two terraces is quite different; the white one lies against a hill of moderate height and gentle slope, appearing from its countless jets of steam to be a hill of fire. The pink one lies against a fine bold hill some two thousand feet high, from which it runs like a steep staircase directly into the lake. They are rival beauties, both deserving many worshipers—the white one, I believe, having the most.

Some of the small mud geysers behind the white terrace were curious; they were growling, and throwing mud of every variety of color

about. One of pale gray mud was said to be eaten by the Maories as medicine; it had a decidedly acid taste. One big hole was blowing off immense volumes of steam with the noise of a dozen steam-engines shrieking in friendly rivalry. A little farther on was a pool of cold vivid green water—greener far than the leaves of the shrubs near it, and strongly charged with sulphuric acid and iron. The wonders of Rotomahana really seemed endless, but, alas! it was Saturday afternoon, and we had to get back to Ohinemutu that night, and, however unwillingly, we were obliged to bid the place farewell.

Strolling about after our evening bath on Sunday, we came across a pool in which there were two Maori young women bathing. When we found they had their pipes with them we sent to the hotel for some beer, and sat down to have a chat with them, and found one of them understood a little English. They said they had been in the water an hour before we came. I wonder they were not boiled, the water was very hot and nasty, and we kept them in at least another hour. This was, I think, the pool which Mr. Trollope speaks of having found himself bathing in with three young women; if so, it has now deteriorated very much, and nothing would have tempted us to venture into its dirty waters.

On Monday we rowed over Lake Rotorua to an island called Mokoia. Sir George Grey told me that at one time he lived on the island; it is, in consequence, still rich in fruit-trees and cultivated ground. A legend of this island reminds one of the story of "Hero and Leander." Hinnemoa, a maiden living on the mainland, one day, on hearing the flute of her lover, Tutanekai, the chief of the island tribe, jumped boldly into the lake and swam across the intervening five miles in safety. Tutanekai scarcely deserved his good fortune, he having a few days before made an attack on the mainlanders and destroyed all their boats. On the highest peak of the island I found myself in a small native burying-ground; it was surrounded by a deep ditch and bank. There were some forty or fifty graves, each marked by a small headstone, but I had not much time to examine them closely, having a proper fear of the unknown penalties incurred by the violation of anything *tapu* or sacred. On our way home, Captain Mair showed us his beautiful collection of native weapons, carved boxes, and wonderful cloaks made of native flax, and feathers, most of them presents from grateful natives, or, as we enviously suggested, bribes.

My friend and I, after saying good-by to the others, started the next morning with the guide Fraser to visit the more southern limits of the hot-spring country. A ride of about thirty-five miles brought us to the Waikato, a large swift-flowing river, the scene of much bloodshed during the war. The canoe that we had expected to cross in was not forthcoming, so that we had to camp where we were; luckily the night was fine, and we had plenty of provisions. We had a fine lunar display: round the moon, for a breadth of about twice its own ap-

parent diameter, there was a ring of bright white light; then came a ring of light brown, deepening outward to purple; then came blue growing into green, that melting into yellow, that deepening through orange into a beautiful red. The series of rings was very perfect, about sixteen times the width of the moon, and lasted, apparently without any change, for several hours.

After crossing the river at daybreak we soon came to a native settlement of Orakei-korako, and there got a native to guide us to the alum cave, for which the place is famous. The entrance to the cave is completely hidden by creepers and magnificent tree-ferns with heavily silvered fronds fully twelve feet in length. Descending the cave some eighty or ninety feet by almost regularly formed steep steps, we found a beautiful pool of clear blue water at the bottom. Of course we bathed in the pool; it was warm, strongly impregnated with alum, and when we were swimming with our backs to the entrance it had, curiously enough, exactly the appearance of getting its light from below. The Maori name for it is "the looking-glass," so called, probably, from its power of reflecting light. The floor and walls of the cave were thickly covered with deposits of pure alum, and the roof was colored in parts with pretty variegated patches resembling marble frescoes.

Soon after leaving the cave my horse broke down, and it was with the greatest difficulty that I got him to the high-road before he succumbed entirely. While waiting to see if he would recover I saw three people riding toward me: one was a smart-looking native in the uniform of the armed constabulary, the second was a lady, and, to my surprise, she too was a native. She wore a tall black hat and dark veil, a dark-blue well-fitting riding habit, a dainty pink-and-white necktie; I afterward saw she wore a pair of French-looking boots, and black-and-white stockings. She was, in fact, a "real dark swell." She talked a little English, and, after hearing of my plight, she made the third rider, an ordinary-looking native, dismount, and give me his horse, he remaining to do what he could for mine. We rode on to a native village, and there had some boiled potatoes and dried peaches for lunch. My fair riding companion soon afterward appeared without the riding habit, but with a dirty clay pipe in her mouth; I fear her civilization, like her dress, was only a new habit, whose greatest charm was the ease with which it could be discarded. I had eventually to walk to Taupo, a township on the biggest lake in the country, where we intended staying a few days.

Major Roberts, the head of the constabulary, who had been asked to help us, kindly provided us with horses, and an orderly as a guide. We first visited the falls of the Waikato; the great broad river is contracted into a narrow channel, not more than thirty feet wide, with precipitous banks, between which the immense volume of water rushes along, one mass of waves and foam, for a distance of about two hun-

dred yards; it then makes a mad leap of about forty feet, and dashes tumbling over rapids with frantic fury for some distance, and then suddenly resumes the quiet dignity of a great river. It is said that a party of sixty stranger natives were once taunted by the residents into trying to shoot the falls in a canoe, and were, as might have been expected, all drowned. The hot springs were much like those we had before seen; the only remarkable one is called the Crow's Nest. The water has formed a perfect hollow cone of silica about ten feet high. On looking into the cone from above it appears to be built of regular layers of large sticks bound together by incrustations of silica. These sticks give the cone its name of the Crow's Nest, but how the nest came to be so made is a mystery.

In the afternoon I took advantage of a doubt as to whether the game laws apply to game on Maori land to shoot some cock-pheasants, although the shooting season does not begin till May. It is very hard on the natives if they are affected by the game laws, for they would have no means of killing the pheasants, which are increasing so rapidly as to threaten to become a perfect plague to them and their small corn cultivation.

In Taupo Lake, besides carp, there is a most excellent little fish resembling whitebait. They, like everything else in this country, have their legend. Some five hundred years ago a chief with a long name came to Taupo, and grieved to find none of his favorite fish in the lake. After failing to introduce them by natural means, he was driven to have recourse to that most enviable power of obtaining whatever he wished that chiefs seemed to have had then, and have so completely lost now. He accordingly took his cloak, tore it up into small pieces, and cast them into the lake, commanding them to become little fishes, and little fishes they became, and there they are in myriads to this day. Fastidious people think they still have a slightly woolly taste, and I know of no better evidence to support the legend.

Our visit to the hot-lake district came to an end at Taupo. We drove thence some seventy or eighty miles to Napier. We were sorry to leave our friends the Maories with the conviction full in our minds that their days will not be long in their land. I devoutly hope that it may never again be necessary to change our present "sugar and flour" policy for one of "blood and iron."—*Fraser's Magazine.*

"PLEASED WITH A FEATHER."

By Professor GRANT ALLEN.

A MURKY London winter afternoon is not exactly a good opportunity for the pursuit of natural history. The snow lies thick on the pavement outside, half melted into muddy slush; while the fog penetrates through the cracks in the woodwork, and the sun struggles feebly athwart the thick yellow sheet which shuts off his rays from the lifeless earth. If I wish to go on a botanical or entomological excursion to-day, I must perforce content myself with a "Voyage autour de ma Chambre." So I rise listlessly from my easy-chair; perambulate the drawing-room in a sulky mood; peer at the Japanese fans on the mantel-shelf; rearrange for the twentieth time those queer little pipkins we brought on our last vacation ramble from Morlaix; pull about my wife's old Chelsea in a savage fit of tidiness; and finally relapse upon the sofa with a fixed determination to be inconsolably miserable for the rest of the day. Evidently I am suffering from that mysterious British epidemic, the spleen, and I may be shortly expected to plunge incontinently over Waterloo Bridge.

Meanwhile, I find a momentary solace in the Indian cushion which lies under my head. A feather is just pushing its sharper end through the morocco-leather groundwork, between those gorgeous masses of gold, silver, and crimson embroidery; which feather I forthwith begin to egg out, by dexterous side pressure, with admirable industry, worthy of a better cause. My wife, looking up from her crewels, mutters something inarticulate about some one who finds some mischief still for idle hands to do; but her obdurate husband pretends inattention, and finally succeeds in catching the feather-end between his finger and thumb. Now that I have successfully pulled it out, I begin to examine it closely, and bethink myself of how, in brighter summer weather, I dissected a daisy for the benefit of such among the readers of the "Cornhill Magazine" as honored me with their kind attention. I shall take a closer look at this feather, and see if it, too, may not serve as a text for a humble lay-sermon concerning the nature and development of feathers in general, and the birds or human beings who wear them.

For the interesting point about a feather is really this, that *it grew*. It was not made in a moment, like a bullet poured red-hot into a mold: its little airy plumes, branched like a fern into tiny waving filaments, were developed by slow steps, piece after piece, and spikelet after spikelet. And what is true of this particular bit of down which I hold in my fingers, trembling like gossamer at every breath and every pulse, is also true of plumage as a whole in the history of animal evolution. To my mind that great fact, that everything has grown, throws a fresh and wonderful interest into every little object which we

can pick up about our fields or our houses. The old view of creation, which represented it as single and instantaneous, made each creature or each organ seem like a mere piece of molded mechanism, with no history, no puzzle, and no recognizable relation to its like elsewhere. But the new view, which represents creation as continuous, progressive, and regular, teaches us to see in every species or every structure a result of previous causes, an adaptation to preëxisting needs. Thus we are enabled to find in a flower, a fruit, or a feather, innumerable clews which lead us back to its ultimate origin, and give delightful exercise to our intelligence in tracing out the probable steps by which this complex whole has been produced.

I often figure to myself the difference between the two ways of regarding natural objects, by means of the initial letters in an ordinary volume, and the initial letters which Mr. Linley Sambourne draws for us so cleverly in "Punch." Look at the big O of a newspaper leader —it is just a mass of metal, poured into a circular or oval type. But look at the big O which the ingenious artist tricks out for us with social allusions or political innuendoes, and what a world of amusement you will find if you take the trouble to spell out all its quaint devices! See how every curl has some playful hit at a noble lord or an honorable member; how every detail smiles with gentle satire at some passing event or some universal topic. Not a touch but has a meaning for those who will seek it; not a careless little smudge in the corner but brims over with deep purpose and infinite wealth of covert mirth. So it is, I think, with flowers, fruits, or feathers, when once we have learned to look for their hidden hints. This little twist points back to some strange fact in the past history of the species; that unobtrusive spur or knob is the clew to whole volumes of botanical or zoölogical lore. Not a detail but tells of the origin and development of the whole; not a tuft, a spot, or a streak but teems with information for the seeker who has found out the method of seeking aright.

Again, to vary our simile, let us visit some ancient British earthwork or Roman camp. If we go as mere rustics, we see in it all nothing more than a broken ridge of earth on the summit of a rolling down. We are not even sure whether it is really the handiwork of man, or some queer natural formation like the Devil's Dike, the Giant's Causeway, and the parallel roads of Glen Roy. But if we go under the guidance of some skilled archæologist, what a flood of light he is able to throw over its history and its meaning! This row of strongholds, he tells us, formed the frontier line, say between the Welsh of Dorset and the Welsh of Devon. Here the Durotriges and Damnonii, the men of the water-vale and the men of the hills, faced one another from their opposite heights. Sweep round your eye in a semicircle along this series of points, overhanging the valley of the Axe, and you will find every higher summit crowned with a "castle," a rude earthwork raised by the men whom our fathers drove out of the land. That

was their Balkan or Suleiman line, their cordon of border forts, their row of beacons to announce the approach of the hostile hill-men on the war-trail against their homes. Then our antiquary would turn to the work itself, and would point out the various parts, the mode of defense, the simple tactics of those primitive Vaubans. Or else he would show us the Roman detail of the later encampment; the square scar that marked the prætorian quarters; the regular succession of gates and defenses. All this he would tell us from the bare inspection of the existing remains, reconstructing the lost history from his stored-up knowledge of like instances elsewhere.

But I am wandering sadly from my London room and my little feather, this wintry afternoon. Let me look at it once more, and try to realize, in like manner, the story involved in its downy vans.

In the first place, this feather, as an anatomist would tell us, is "a dermal modification"—in other words, an altered bit of the skin. Every part of a plant or animal undergoes changes, our modern teachers say, just in accordance with the external influences which affect it. But the skin of an animal is naturally exposed to many more such surrounding agencies than its internal organs. Accordingly, we find that no structure exhibits such strange variations as the skin. Besides the regular modifications which we see in the scales or horny plates of fishes, the smooth coats or solid shells of reptiles, the feathers of birds, and the hair of mammals, numerous other minor peculiarities occur in almost every species. Such are the horns of cows and goats, the spike of the rhinoceros, the beaks, nails, claws, hoofs, and talons of beasts or birds, and the tail-plumes, ruffs, lappets, crests, and ornamental adjuncts of all the more æsthetic animals. In no class are these variations in the external covering more conspicuous than among the biped tribe whose spoils I am now holding in my hand as the text for our afternoon's discourse.

How birds first came to be winged and feathered we can hardly say as yet. To be sure, most of us have seen a picture, at least, of that strange oölitic monster, the pterodactyl, a saurian with a head like a crow, but having the fore-part protracted into long jaws, fitted with teeth not very dissimilar from those of a crocodile; while its legs were supplied, apparently, with a membrane, by whose aid the creature probably flew about in the same manner as a bat. These real flying dragons recall in many points the appearance of a bird, especially in the skull and the position of the eyes. Moreover, Professors Marsh and Huxley have shown that the earliest fossil birds resemble the pterodactyl and other reptiles in many important peculiarities of structure, far more than their modern representatives. Some of them even possess teeth set in their jaws after a reptilian fashion. Though the evidence still remains very fragmentary, we may regard it as probable that birds are descended from some early reptilian form, more or less like the peterodactyl, if not actually from that partially-winged saurian

itself. But perhaps it is premature to build with any confidence upon such dubious ground; and we may consequently accept the earliest birds on their own responsibility, without inquiring too curiously into their antecedents, or compelling them to produce a genealogical table of their ancestry.

The essential characteristic of a bird consists in the fact that it is a flying animal; and feathers are the kind of skin-covering best adapted to its special manner of life. In their nature and mode of development, feathers closely agree with the hair of mammals; but the differences between them are all of a sort which fit the bird for its aërial existence. We see this fact very clearly if we look at the instance of those birds which do not fly. Running species, such as the ostriches, have downy plumes, in which many of the essential characters of the feather are greatly obscured. In the emu, whose habits are more strictly cursorial, the plumage almost resembles hair. In the cassowary the likeness becomes yet more striking, while the wingless apteryx of New Zealand has not even the few bare quills which stand for wing-feathers in the former bird. So, too, among those sedentary marine birds, the penguins, where the wings have been converted into a sort of fins for diving, the feathers undergo a parallel change into scales. There is reason, indeed, to suspect, as Mr. Lowne has pointed out, that these marine species retain in many ways the primitive characters of the class; and we may perhaps regard them rather as birds in whom the pinions and plumage have never fully developed than as birds in whom they have assumed a new form.

On the other hand, the truest feathers—that is to say, those which exhibit the essential features of a feather in the most marked manner—are specially connected with the act of flight. The general surface of the body is covered with soft down, among which sprout the delicate plumes that form the common covering for warmth and protection; but only on the wings and tail do those long and stiff quills appear which, after all, are the feathers *par excellence*, the models and prototypes of all the rest. Now, it is quite obvious to every one that the wings are the organs of flight, and that the quills are the part by means of which the powerful muscles of the bird are brought to bear upon the sustaining atmosphere. As for the tail, its functions resemble those of a rudder, in directing the course of flight to right or left. The difference between these true flying feathers and the mere clothing of the back and breast is so striking that naturalists have given them separate technical names, as *quills* and *plumes* respectively.

From such facts, and others like them, I think we may arrive at an important conclusion—that feathers have been developed and selected through the habit of flight. Probably our monstrous friend the pterodactyl had only a membranous wing or bit of skin, extending from the elongated outer finger of his forearm to the leg. Such a parachute we still see among the so-called flying-squirrels and lemurs; while in the

bats it has developed into a sort of webbed wing. But if any of the early birds happened to possess an altered hair-like or scale-like covering—the relic, perhaps, of some common reptilio-mammalian ancestor—which afforded them any extra grip upon the air through which they fell rather than floated, then those individuals would thereby gain an extra chance of catching prey or escaping enemies, and therefore of survival in the constant rivalry of species with species. The more perfect these organs became, the more closely adapted to the function of flight, the greater the advantage the bird would derive from their possession, and therefore the better the chance of survival which it would obtain. Thus, apparently, the most aërial birds have the largest and strongest quills, and the most quill-like plumes, while the running and diving birds have either never developed these adjuncts in their highest form, or else have lost them by disuse.

Let me take down one of the peacock's feathers, which stands on the mantelpiece in this Vallauris vase, and closely examine its structure. It consists of a long central shaft, horny and tubular at the lower end, and filled above with a soft, white, spongy matter; while a number of little barbed branches are given off on either side, curiously interlaced by means of tiny hooked filaments, whose myriad threads are far too numerous for the most industrious critic to count up. Everybody knows that this tubular structure combines in the highest degree the mechanical requisites of lightness and strength; and everybody has read that it is employed with the self-same object by human engineers, in such constructions as the great bridges which span the Menai Straits or the St. Lawrence at Montreal. Evidently this peacock's feather, though now converted to a purely ornamental function, was originally developed for the purpose of flight. If I doubt it for a moment, I need only look at the quill-pen in my desk over yonder. That flat blade, close-textured and strongly woven, clearly belongs to a flying organ; and this beautiful mass of green and golden waving plumelets is evidently modeled on the self-same plan. It is useless, or next to useless, now, for flight; but it still bears clear traces of its original function in the structure and arrangement of its shaft and barbs.

Next, let me look at the little downy feather I have abstracted from the Indian cushion. This is not a flying organ, nor did its representative on any early ancestor ever fulfill a similar office. Light, warm, soft, fluffy, its whole object is decidedly that of clothing against chilly weather, and protection against thorns or other rough bodies. Yet when I examine it closely, I see that the same general ground-plan still runs through it, as that which ran through the goose-quill and the peacock's tail-covert. "How comes this?" I ask myself; "here we have a small, delicate, almost fleshy shaft, instead of the horny quill; and a feeble set of downy barbs instead of the strong, well-woven blade: yet the main features remain unaltered, though the function is entirely different. How can I account for this resemblance?"

The case of the emu and the apteryx helps to throw light upon the problem thus disclosed. Where birds fly very little, their feathers never acquire or else soon lose the distinctive quill-like character; but where birds fly much, the quill-producing tendency becomes strong and pronounced. Primarily, this tendency ought to affect only those parts which are used in flight, namely, the wings and tail; and, as a matter of fact, we have seen that these are the parts which exhibit it in the highest degree. It would be almost impossible, however, that a change of such magnitude should be set up in some of the feathers, without to a lesser extent affecting all the rest. We might as well expect that the hair on a certain patch of some animal's skin would grow thick and spike-like, without any corresponding alteration in the rest of his body. True, natural selection does sometimes produce this result for some special purpose, when it is highly desirable that an acquired character should be confined to a small area. But, as a rule, when one part of the skin hardens, like that of a turtle or crocodile, the tendency to bony development shows itself in every part; and when certain hairs become converted into thick spines, like those of the hedgehog, the echidna, and the porcupine, a general bristly tone pervades almost all the coat. The scaly plates of the armadillo and the pangolin in like manner communicate a universal scaliness to the whole external surface of the animal. We may say in simple language that the body has *got into the habit* of producing certain structures, and that the habit extends to analogous parts in which it is not strictly necessary.

This is the case with the flying birds. Some of their feathers—modified scales or hairs—having become specially adapted for flying, all the rest follow suit to a greater or less extent. Indeed, we can hardly imagine how quills could come into existence at all, unless we allow that there must first have been an adventitious tendency toward the production of light-barbed shafts over the whole body. Those birds which exhibited this adventitious habit in the highest degree would become the ancestors of the aërial species, in whom it is still further developed by natural selection; while those birds which exhibited it in the least degree would become the ancestors of the diving, running, and scraping tribes, in whom natural selection favors rather such special adaptations as web-feet, fin-like wings, long and powerful legs, and ornamental plumage.*

The æsthetic philosopher, however (if the reader will permit me to

* Of course no effect in nature is really *accidental*, that is to say, uncaused; but, in organic nature, effects which arise from special collocations of causes, unconnected with the previous habits of a plant or animal, may fairly be called *adventitious*. If they result in some alteration beneficial to the species, the alteration will be further strengthened by natural selection, and its final outcome will be a *purposive* structure—that is to say, a structure specially adapted to its peculiar function. But it must be remembered that almost all purposive structures were in their origin adventitious. I say "almost all" and not "all," because an exception must be made in favor of what Mr. Herbert Spencer calls "functionally-produced structures."

designate myself by such a periphrasis), is far more interested in the modifications which feathers undergo, *after* they have become feathers, than in those which they undergo before reaching that stage of their development. For the infinite variety of coloring, the exquisite tones of metallic sheen, the graceful arrangements of crests, tufts, plumes, and lappets, which render birds such conspicuous objects in our museums or gardens, are all of them due to the pigments or shapes of feathers, and all of them have apparently been produced by the voluntary choice of beautiful mates among the birds themselves.

The modifications of feathers thus originated form, of course, a clew to the tastes of the various birds which possess them; because each species will naturally select such mates as best satisfy its ideas of the beautiful, and so will transmit the admired qualities to its descendants. It is a remarkable fact that the tastes of many birds, indirectly disclosed in such a manner, coincide very closely with the tastes of mankind at large.

Not all birds, however, exhibit equally these æsthetic preferences. Some large families, like those of the hawks, eagles, owls, and night-jars, are noticeable neither for beauty of color nor for richness of song. Other classes, again, like those of our own English hedge-birds, seem rather musical than chromatically inclined in their tastes. As a rule, we may say that birds of prey and nocturnal birds are very deficient in æsthetic feeling, all their energies being apparently directed to swiftness of pursuit and skill in hunting; while, on the other hand, small seed-eating birds, and those which live on little insects or other minute animals, generally expend all their æsthetic sentiment on the faculty of song. But only those birds which live upon fruits, or the mixed nectar and insects extracted from flowers, usually possess brilliant colors.

I have already more than once pointed out to the readers of the "Cornhill Magazine" the probable reason for this peculiar connection.* The eyes of fruit-eating or flower-feeding animals become specially adapted to the stimulation of colored light, and therefore the creatures become capable of receiving special pleasure from such sources. Accordingly, those among their fellows which displayed brilliant colors would prove most attractive, and would be chosen as mates for their beauty. I have instanced before, among the flower-feeding species, the numberless varieties of humming-birds, and the almost equal profusion of sun-birds, to which we may add a few other minor forms, such as the brush-tongued lories; while among the fruit-eaters, the parrots, macaws, cockatoos, toucans, barbets, nutmeg-pigeons, fruit-pigeons, chatterers, and birds-of-paradise, may stand as cases in point. But it will be more interesting here to glance briefly at the various modes in which these colors are produced than to extend the list of species which display them.

* See a paper on "The Origin of Flowers," in "The Popular Science Monthly Supplement" for June, 1878; and another on "The Origin of Fruits," in "The Popular Science Monthly" for September, 1878.

The commonest method of exhibiting color is by means of pigments either in the external coating of the feathers or in their deeper layers. Cases of this sort are too frequent to need special exemplification; but some birds have brilliant hues otherwise displayed, as in the wattles of the common barn-door fowl, the fleshy appendages of the turkey, and the painted face of the carrier-pigeon. The wattled honey-sucker of Australia has two drooping folds of flesh which fall like bonnet-strings under his throat; the king-vulture has his head and neck covered with naked skin of every hue in the rainbow; and the cassowary (by far the most frugivorous of all the ostrich tribe) has the same parts of a brilliant red, variegated with melting shades of blue. In many other birds the beak becomes an ornamental adjunct; and this tendency reaches its furthest development in the bill of the toucan, whose colors almost vie with the humming-bird itself. But the most curious of all such æsthetic modifications is that from which the wax-wings derive their name. In these birds the shafts of certain wing-feathers are prolonged into small, horny expansions, bright scarlet in hue, exactly resembling, both in color and texture, little tags of red sealing-wax.

The metallic luster of feathers is generally due to fine lines on the surface of the barbules, like those which produce the iridescence of mother-of-pearl. Such luster occurs in the sun-birds and humming-birds, and on many other less ornamented species. Sometimes gleaming like gold or bronze, sometimes fading away into jetty black, anon reappearing as glancing outbursts of crimson, azure, or exquisite green, it has gained for the birds on which it appears such poetical names as ruby-throated, topaz-crested, amethystine, golden, emerald, and sapphire. Not only does it occur upon the burnished neck of the dove, but it gives a passing splendor to the sable livery of the crow, and throws a thousand changeful hues over the glossy plumage of the mallard.

But besides the ornamental effects of color and luster, feathers appeal to the æsthetic taste of birds by their form, their arrangement, and their variety. Only the plainest birds have all their plumage exactly uniform and simply disposed. In an immense number of species certain feathers have been specially modified in shape so as to form crests, fan-like tails, lappets, and other ornaments. And just as a good architect lavishes his decorations chiefly on the constructive points of his building, the critical parts, such as arches, doorways, windows, and architraves, so do we find that birds have chosen to place *their* decorative modifications on the most important nodal points of their bodies, and that they generally lavish their richest coloring upon these ornamental adjuncts. This peacock's feather, for instance, formed part of a gorgeous semicircular fan, which composed, as it were, the background or reredos of the whole living picture when expanded, and the train of the majestic sultan when folded in repose. A plume from the neck or back, though still beautiful with golden green and

faintly purplish blue, would not have exhibited those splendid eye-like spots which reflect the sunlight in a mingled mass of glory from this perfect tail-covert. Only in the most fitting positions for decoration do birds, as a rule, expend their choicest designs.*

The feathers of the ostrich naturally occur first to the human investigator of æsthetic taste in birds. The quills of the wing and tail, here purely ornamental in their function, compose the well-known silky plumes of commerce. The common crane has also beautiful elongated wing-feathers, which fall on either side of the tail in graceful waving masses. If we may trust the doubtful pictures which have come down to us, that grotesque and gigantic pigeon, the dodo, possessed similar tufts of ornamental plumage. But the great order of gallinaceous birds, or the hen and turkey tribe, display the most magnificent tails of all, so familiarly known in the peacock and the pheasant family, as well as in the humbler denizens of our English farmyards.

Crests form another favorite ornamental device among birds, occurring independently in the most different orders. The graceful tuft of the gray heron must have attracted the attention of every observer. Among the pheasants similar decorative adjuncts are common; and the curassow shows this peculiarity in a very beautiful form. With parrots and cockatoos, crests are of frequent occurrence, and they make equally striking features among the humming-birds and sun-birds. Indeed, it may be roughly asserted that those birds which seek their food among flowers and fruits, and which consequently exhibit a taste for bright colors, are also the species in which ornamental tufts of feathers most frequently occur. But crests are also found even among the generally somber and inartistic birds of prey, being by no means unusual in the owls and hawks, while the serpent-eating secretary-bird derives his queer name from the fancied resemblance of his top-knot to a pen stuck behind the ear. Other well-known instances of crested species are the hoopoe, the wax-wing, the golden-crested wren, and many jays. But the umbrella-bird, a Brazilian fruit-crow, exhibits the fullest development of this particular ornament, having the whole head covered by a dome of slender, shining blue feathers, about five inches in length by four and a half in breadth. It may be added that almost all birds which possess these ornaments possess also the power of raising or depressing them at will; and that during the season of courtship the male birds constantly expand all their charms before the eyes of their admiring mates. We have all seen this ostentatious display ourselves in the case of the peacock, the turkey, and the barn-door fowl. It proves almost beyond a doubt the æsthetic purpose and func-

* I say "as a rule," because the hornbills, toucans, vultures, certain pigeons, and a few other species, offend against our ordinary human canons of taste; but the ornaments of birds seldom or never render them ridiculous in our eyes, like those of many highly decorated monkeys.

tion of such otherwise useless, inconvenient, and vitally expensive excrescences.

Sometimes the crest is produced by some other means than that of a mass of plumes. Besides the well-known fleshy comb of our friend chanticleer, there is the horny helmet of our old acquaintance the cassowary, and the quaint protuberances on the beak of the jacana. Most eccentric of all is the device adopted by the hornbills, whose name sufficiently indicates their peculiarity in this respect. The beak in these birds is prolonged above into a single unicorn-like process, extravagantly disproportioned to the general size of its wearer.

On the other hand, it may be noted that most small singing-birds, or other species which live on seeds, grains, insects, and mixed small food, are destitute of tufted ornaments, as well as of brilliant coloring.

The lappets, frills, or other neck-pieces of so many decorated species must not pass entirely unnoticed in this review of æsthetic devices among birds. Beginning with the mere burnished breast-plumage of the pigeon, or the crimson stomacher of the robin, they become at last, in the humming-birds, sun-birds, and other tropical species, the most exquisite drapery of amethyst, topaz, emerald, or golden bronze. The so-called beard of the turkey is a special example of a very aberrant type. The ruff derives his English name from a similar peculiarity.

The birds-of-paradise unite all these modes of ornamentation in the highest degree, and with the most harmonious results. They join the graceful plumes of the ostrich to the dainty coloring of the sun-bird. Crests almost as largely developed as that of the umbrella-bird overshadow their beautiful heads; frills as full as those of the humming-birds fall down in metallic splendor before their gorgeous necks. And, if any proof be wanting of the connection between the nature of the food and the general beauty of the plumage, it may be found in the fact that these royally-attired creatures are first cousins of our own dingy crows and jackdaws; but, while the crow seeks his livelihood among the insects and carrion of an English plowed field, the bird-of-paradise regales his lordly palate on the crimson and purple fruits which gleam out amid the embowering foliage of Malayan forests.

Equally magnificent are the members of the genus *Epimachus*, inhabitants of the same brilliant archipelago. Their long, silky plumes float behind them in the same graceful curves; their burnished necks are adorned with the same glancing hues of ruby and emerald. Yet they are surpassed in one respect by their distant relatives, the lyre-birds, first cousins of our diminutive English wrens. Though destitute of brilliant coloring and metallic sheen, these curious birds exhibit in their long and beautiful tails the only undoubted example among the lower animals of a love for symmetrical patterns.

I have only bethought me now of a few among the countless modifications which feathers undergo, for the æsthetic gratification of their

wearers, or rather of their wearers' mates, and the list might be almost indefinitely prolonged. But it will be better worth while, perhaps, to glance briefly at another set of facts connected with feathers—I mean their artificial employment by human beings for the exactly identical purpose of æsthetic decoration. Could any fact show more clearly the similarity of artistic feeling which runs through the whole animal series than this thought, that man makes use, for his own adornment, of the very self-same beautiful colored baubles which the birds originally developed to charm the eyes of their fastidious brides?

I need not recall by name the various kinds of plumage so employed—the feathers of the ostrich, the marabou, the bird-of-paradise, the emu, the pheasant, and the gull; the sun-birds and the humming-birds mercilessly slaughtered by the million in the Malay Archipelago, Ceylon, and Trinidad to supply the bonnets of London and Paris; the swan's-down, the grebe, the widow-birds, the cockatoos, the parrots, the macaws, which decorate our wives and children with barbaric spoils. It will suffice to remember, in passing, that from the feather mantles of Hawaian kings, the feather kirtles of American Indians, and the feather mosaics of Mexico, to the plumes of our own court-dress, our own military uniforms, and our own quaintly surviving funeral processions, these same "dermal modifications" of birds have served an æsthetic purpose, better or worse, throughout the whole course of human history.

Nor does the resemblance stop here. Mankind employs tufts of feathers for decorative display in just the same manner as the birds who originally developed them. The Red Indian in his war-paint dressed out his head with a row of quills, arranged in exactly the same order as the top-knot of a hoopoe or a cockatoo. The feather collars of so many savage tribes recall to the letter the frills and lappets of the humming-bird or the epimachus. The ostrich-plumes of our English royal receptions, and the *panache* of our European officers' dress, are adaptations from the primitive idea of the crane and the umbrella-bird. Everywhere, the tuft of feathers is placed on some prominent part of the person—some "constructive point" in the human or avian system of architecture.

A ring at the bell warns me that a visitor is standing at the door. I throw my little feather hastily into the fire, and cut short my reflections to welcome my expected guest. But one last thought occurs to me before I close my afternoon's meditation. To be "pleased with a feather" appeared to the great metaphysical poet of the eighteenth century a mark of childish simplicity. Perhaps it may be so; but, after all, is there not some solace in that new philosophy which can enable one to pass a whole hour, this murky afternoon, in pleasurable contemplation of that tiny plume which seems no contemptible subject of human study to Charles Darwin and Herbert Spencer?—*Cornhill.*

FOOD AND FEEDING.

By Sir HENRY THOMPSON.

I.

I THINK I shall not be far wrong if I say that there are few subjects more important to the well-being of man than the selection and preparation of his food. Our forefathers in their wisdom have provided, by ample and generously endowed organizations, for the dissemination of moral precepts in relation to human conduct, and for the constant supply of sustenance to meet the cravings of religious emotions common to all sorts and conditions of men. In these provisions no student of human nature can fail to recognize the spirit of wisdom and a lofty purpose. But it is not a sign of ancestral wisdom that so little thought has been bestowed on the teaching of what we should eat and drink; that the relations, not only between food and a healthy population, but between food and virtue, between the process of digestion and the state of mind which results from it, have occupied a subordinate place in the practical arrangements of life. No doubt there has long been some practical acknowledgment, on the part of a few educated persons, of the simple fact that a man's temper, and consequently many of his actions, depends on such an alternative as whether he habitually digests his food well or ill; whether the meals which he eats are properly converted into healthy material, suitable for the ceaseless work of building up both muscle and brain; or whether unhealthy products constantly pollute the course of nutritive supply. But the truth of that fact has never been generally admitted to an extent at all comparable with its exceeding importance. It produces no practical result on the habits of men in the least degree commensurate with the pregnant import it contains. For it is certain that an adequate recognition of the value of proper food to the individual in maintaining a high standard of health, in prolonging healthy life (the prolongation of unhealthy life being small gain either to the individual or to the community), and thus largely promoting cheerful temper, prevalent good nature, and improved moral tone, would require almost a revolution in the habits of a large part of the community.

The general outlines of a man's mental character and physical tendencies are doubtless largely determined by the impress of race and family. That is, the scheme of the building, its characteristics and dimensions, are inherited; but to a very large extent the materials and filling in of the framework depend upon his food and training. By the latter term may be understood all that relates to mental and moral and even to physical education, in part already assumed to be fairly provided for, and therefore not further to be considered here. No matter, then, how consummate the scheme of the architect, nor

how vast the design, more or less of failure to rear the edifice results when the materials are ill chosen or wholly unworthy to be used. Many other sources of failure there may be which it is no part of my business to note; but the influence of food is not only itself cardinal in rank, but, by priority of action, gives rise to other and secondary agencies.

The slightest sketch of the commonest types of human life will suffice to illustrate this truth.

To commence, I fear it must be admitted that the majority of British infants are reared on imperfect milk by weak or ill-fed mothers. And thus it follows that the signs of disease, of feeble vitality, or of fretful disposition, may be observed at a very early age, and are apparent in symptons of indigestion or in the cravings of want manifested by the "peevish" and sleepless infant. In circumstances where there is no want of abundant nutriment, over-feeding or complicated forms of food, suitable only for older persons, produce for this infant troubles which are no less grave than those of the former. In the next stage of life, among the poor the child takes his place at the parents' table, where lack of means, as well as of knowledge, deprives him of food more suitable than the rough fare of the adult, and moreover obtains for him, perchance, his little share of beer or gin. On the whole, perhaps he is not much worse off than the child of the well-to-do, who becomes a pet, and is already familiarized with complex and too solid forms of food and stimulating drinks which custom and self-indulgence have placed on the daily table. And soon afterward commence in consequence—and entirely in consequence, a fact it is impossible too much to emphasize—the "sick-headaches" and "bilious attacks," which pursue their victim through half a lifetime, to be exchanged for gout or worse at or before the grand climacteric. And so common are these evils that they are regarded by people in general as a necessary appanage of "poor humanity." No notion can be more erroneous, since it is absolutely true that the complaints referred to are self-engendered, form no necessary part of our physical nature, and for their existence are dependent almost entirely on our habits in relation to food and drink. I except, of course, those cases in which hereditary tendencies are so strong as to produce these evils, despite some care on the part of the unfortunate victim of an ancestor's self-indulgence. Equally, however, on the part of that little-to-be-revered progenitor was ill-chosen food, or more probably excess in quantity, the cause of disease, and not the physical nature of man.

The next stage of boyhood transfers the child just spoken of to a public school, where too often insufficient or inappropriate diet, at the most critical period of growth, has to be supplemented from other sources. It is almost unnecessary to say that chief among these are the pastrycook and the vender of portable provisions, for much of

which latter that skin-stuffed compound of unknown origin, an uncertified sausage, may be accepted as the type.

After this period arise the temptations to drink, among the youth of all classes, whether at beerhouse, tavern, or club. For it has been taught in the bosom of the family, by the father's example and by the mother's precept, that wine, beer, and spirits are useful, nay, necessary to health, and that they augment the strength. And the lessons thus inculcated and too well learned were but steps which led to wider experience in the pursuit of health and strength by larger use of the same means. Under such circumstances it often happens, as the youth grows up, that a flagging appetite or a failing digestion habitually demands a dram before or between meals, and that these are regarded rather as occasions to indulge in variety of liquor than as repasts for nourishing the body. It is not surprising, with such training, that the true object of both eating and drinking is entirely lost sight of. The gratification of acquired tastes usurps the function of that zest which healthy appetite produces; and the intention that food should be adapted to the physical needs of the body and the healthy action of the mind is forgotten altogether. So it often comes to pass that at middle age, when man finds himself in the full current of life's occupations, struggling for preëminence with his fellows, indigestion has become persistent in some of its numerous forms, shortens his "staying power," or spoils his judgment or temper. And, besides all this, few causes are more potent than an incompetent stomach to engender habits of selfishness and egotism. A constant care to provide little personal wants of various kinds, thus rendered necessary, cultivates these sentiments, and they influence the man's whole character in consequence. The poor man, advancing in years, suffers from continuous toil with inadequate food, the supply of which is often diminished by his expenditure for beer, which, although often noxious, he regards as the elixir of life, never to be missed when fair occasion for obtaining it is offered. Many of this class are prematurely crippled by articular disease, etc., and become permanent inmates of the parish workhouse or infirmary.

It must be obvious to everybody how much more of detail might be added to fill in the outlines of this little sketch. It is meager in the extreme: nevertheless it suffices for my purpose; other illustrations may occur hereafter.

But it is necessary to say at this point, and I desire to say it emphatically, that the subject of food need not, even with the views just enunciated, be treated in an ascetic spirit. It is to be considered in relation to a principle, in which we may certainly believe, that aliments most adapted to develop the individual, sound in body and mind, shall not only be most acceptable, but that they may be selected and prepared so as to afford scope for the exercise of a refined taste, and produce a fair degree of that pleasure naturally associated with the

function of the palate, and derived from a study of the table. For it is certain that nine tenths of the gormandism which is practiced, at all events in English society—where for the most part it is a matter of faith without knowledge—is no more a source of gratification to the eater's gustatory sense than it is of digestible sustenance to his body.

Our subject now shapes itself. Food must first be regarded in relation to its value as material to be used for building up and sustaining that composite structure, the human body, under the varied conditions in which it may be placed. Secondly, the selection of food, and the best modes of preparing it, resulting in the production of "the dish," a subject of great extent and importance, must be dealt with very briefly. Lastly, the exercise of taste in relation to the serving of food and drink, or the art of combining dishes to form "a meal," must also be considered.

I shall not regard this as the place in which to offer any scientific definition of the term "food." I shall include within its range all the solid materials popularly so regarded, and therefore eaten. And drink being as necessary as solids for the purpose of digestion, and to supply that large proportion of fluid which the body contains in every mesh and cell thereof, I shall regard as "drink" all the liquids which it is customary to swallow with our meals, although probably very few, if any, of them can be regarded as food in any strict sense of the term.

Food is essential to the body in order to fulfill two distinct purposes, or to supply two distinct wants inseparable from animal life. As certainly as a steam-engine requires fuel, by the combustion or oxidation of which force is called into action for various purposes—as the engine itself requires the mending and replacing of parts wasted in the process of working—so certainly does the animal body require fuel to evoke its force, and material to replace those portions which are necessarily wasted by labor, whether the latter be what we call physical or mental—that is, of limbs or of brain. The material which is competent to supply both requirements is a complete or perfect food. Examples of complete food exist in milk and the egg, sufficing as these do for all the wants of the young animal during the period of early growth. Nevertheless, a single animal product like either of the two named, although complex in itself, is not more perfect than an artificial combination of various simpler substances, provided the mixture (dish or meal) contains all the elements required in due proportion for the purposes of the body.

It would be out of place to occupy much space with those elementary details of the chemical constitution of the body which may be found in any small manual of human physiology;* but for the right

* Such as "Physiology," Science Primer, by M. Foster, M. A., M. D. (Macmillan); "Lessons in Elementary Physiology," by Professor Huxley (Macmillan). For a full consideration of the subject, Dr. Pavy's very complete "Treatise on Food and Dietetics" (Churchill, London, 1875).

understanding of our subject, a brief sketch must be presented. Let it suffice to say that carbon, hydrogen, and oxygen, the three all-pervading elements of the vegetable world, enter largely into the composition of the animal body; and that the two former especially constitute a fuel the oxidization of which produces animal heat, and develops the force in its varied forms, physical and mental, which the body is capable of exerting. Besides these, nitrogen, obtainable from certain vegetable products, not from all, but forming definite combinations with the three elements just named, is essential to the repair and reproduction of the body itself, being one of its most important constituents. Lastly must be named several other elements which, in small proportions, are also essential constituents of the body, such as sulphur, phosphorus, salts of lime, magnesia, potash, etc., with traces of iron and other metals. All these must be present in the food supplied, otherwise animal existence can not be supported; and all are found in the vegetable kingdom, and may be obtained directly therefrom by man in feeding on vegetables alone.* But the process of obtaining and combining these simple elements into the more complex forms which constitute the bases of animal tissues—definite compounds of nitrogen with carbon, hydrogen and oxygen—is also accomplished by the lower animals, which are exclusively vegetable feeders. These animals we can consume as food, and thus procure, if we please, ready prepared for our purpose, the materials of flesh, sinew, and bone for immediate use. We obtain also from the animal milk and the egg, already said to be "perfect" foods; and they are so because they contain the nitrogenous compounds referred to, fatty matter abundantly, and the various saline or mineral matters requisite. But compounds simpler in form than the preceding, of a non-nitrogenous kind, that is, of carbon, hydrogen, and oxygen only, are necessary as food for the production of animal heat and force. These consist, first, of the fat of animals of various kinds, and of butter; and from the vegetable kingdom, of the fatty matter which exists in grain and legumes, and largely in the olive and in many seeds; secondly, of the starchy matters, all derived from vegetables, such as a large part of wheaten and other flour, rice, arrowroot, and potatoes, together with sugar, gum, and other minor vegetable products of a similar kind. The fats form the more important group of the two, both in relation to the production of heat and force; and without a constant supply of fat as food the body would cease to exist. The vegetable-eater, pure and simple, can therefore extract from his food all the principles necessary for the growth and support of the body as well as for the production

* The vegetable kingdom comprehends the cereals, legumes, roots, starches, sugar, herbs, and fruits. Persons who style themselves vegetarians often consume milk, eggs, butter, and lard, which are choice foods from the animal kingdom. There are other persons, of course, who are strictly vegetable-eaters, and such alone have any right to the title of vegetarians.

of heat and force, provided that he selects vegetables which contain all the essential elements named. But he must for this purpose consume the best cereals, wheat or oats, or the legumes, beans, peas, or lentils; or he must swallow and digest a large weight of vegetable matter of less nutritive value, and therefore containing at least one element in large excess, in order to obtain all the elements he needs. Thus the Irishman requires ten to eleven pounds of potatoes daily, which contain chiefly starch, very little nitrogen, and scarcely any fat; hence he obtains, when he can, some buttermilk or bacon, or a herring to supply the deficiency. The Highlander, living mainly on oatmeal, requires a much smaller weight, since this grain contains not only starch, but much nitrogen and a fair amount of fat, although not quite sufficient for his purpose, which is usually supplied by adding milk or a little bacon to his diet. On the other hand, the man who lives chiefly or largely on flesh and eggs as well as bread obtains precisely the same principles, but served in a concentrated form, and a weight of about two or three pounds of such food is a full equivalent to the Irishman's ten or eleven pounds of potatoes and extras. The meat-eater's digestion is taxed with a far less quantity of solid, but that very concentration in regard of quality entails on some stomachs an expenditure of force in digestion equal to that required by the vegetable-eater to assimilate his much larger portions. And it must be admitted as a fact beyond question that some persons are stronger and more healthy who live chiefly or altogether on vegetables, while there are many others for whom a proportion of animal food appears to be desirable, if not necessary. In studying this matter individual habit must be taken into account. An animal feeder may by slow degrees become a vegetarian, without loss of weight or strength, not without feeling some inconvenience in the process; but a sudden change in diet in this direction is for a time almost equivalent to starvation. The digestive organs require a considerable period to accommodate themselves to the performance of work different from that to which they have been long accustomed, and in some constitutions might fail altogether in the attempt. Besides, in matters of diet essentially, many persons have individual peculiarities; and while certain fixed principles exist, such as those already laid down as absolutely cardinal, in the detail of their application to each man's wants an infinity of stomach eccentricities is to be reckoned on. The old proverb expresses the fact strongly but truly: "What is one man's meat is another man's poison." Yet nothing is more common—and one rarely leaves a social dinner-table without observing it—than to hear some good-natured person recommending to his neighbor, with a confidence rarely found except in alliance with profound ignorance of the matter in hand, some special form of food or drink, or system of diet, solely because the adviser happens to have found it useful to himself!

It will be interesting now to take a general but brief survey of the

vast range of materials which civilized man has at his command for the purpose of food: these few preliminary remarks on the chemical constituents of food having been intended to aid in appreciating the value of different kinds.

Commencing with the vegetable kingdom, from which our early progenitors, probably during long ages, drew all their sustenance, the cereals, or cultivated grasses, come first, as containing all the elements necessary to life, and being therefore most largely consumed. Wheat and its congeners, which rank highest in quality, had been distinguished in the form of bread, as "the staff of life," long before the physiological demonstration of the fact had been attained. Wheat, oats, rye, and barley, maize and rice, are the chief members of this group; wheat containing the most nitrogenous or flesh-forming material, besides abundance of starch, a moderate amount of fat, together with sufficient saline and mineral elements. Rice, on the other hand, contains very little nitrogen, fat, and mineral constituents, but starch in great abundance; while maize, with a fair supply of nitrogenous and starchy matter, contains the most fat or heat-producing material of the whole group. As derived from wheat must be named the valuable aliments, macaroni and all the Italian pastes. Derived from barley is malt-saccharine, parent of the large family of fermented liquors known as beer. And from various other grains are obtained, by fermentation and distillation, several forms of ardent spirit. Vinegar, best when produced from the grape, is also largely made from grain.

The legumes, such as beans, lentils, and peas, form an aliment of great value, containing more nitrogen even than the cereals, but with fat in very small proportion, while starchy matter and the mineral elements abound in both groups.

The tuber finds its type in the potato, which contains much starch, little nitrogen, and almost no fat; in the yam also. The roots may be illustrated by the beet, carrot, parsnip, and turnip, all containing little nitrogen, but much sugar, and water in large proportion. Derived from roots and stems of foreign growth, we have arrowroot, tapioca, and sago, all starches and destitute of nitrogen. Fatty matter is abundantly found in the olive, which supplies a large part of the world with an important article of food. The almond and other seeds are also fruitful sources of oil.

Under the term "green vegetables," a few leading plants may be enumerated as types of the vast natural supplies which everywhere exist: The entire cabbage tribe in great variety; lettuces, endive, and cresses; spinach, seakale, asparagus, celery, onions, artichokes, and tomato, all valuable not so much for nutritive property, which is inconsiderable, as for admixture with other food chiefly on account of salts which they contain, and for their appetizing aroma and varied flavors. Thus condiments are useful, as the sweet and aromatic spices, the peppers, mustard, and the various potherbs, so essential to an agreeable

cuisine. Sea-weeds, as laver, and the whole tribe of mushrooms should be named, as ranking much higher in nutritive value than green vegetables. Pumpkins, marrows, and cucumbers, chestnuts, and other nuts largely support life in some countries. The bread-fruit is of high value; so also are the cocoanut and the banana in tropical climates.

Lastly must be named all those delicious but not very nutritive products of most varied kind and source, grouped under the name of fruits. These are characterized chiefly by the presence of sugar, acid, vegetable jelly, and some saline matter, often combined with scent and flavor of exquisite quality. Derived from grapes as its chief source, stands wine in its innumerable varieties, so closely associated by all civilized nations with the use of aliments, although not universally admitted to rank in technical language as a food. Next may be named sugar in its various forms, a non-nitrogenous product of great value, and in a less degree, honey. No less important are the tea-plant, the coffee-berry, and the seeds of the cacao-tree.

There is a single element belonging to the mineral kingdom which is taken in its natural state as an addition to food, namely, common salt; and it is so universally recognized as necessary that it can not be omitted here. The foregoing list possesses no claim to be exhaustive, only to be fairly typical and suggestive; many omissions, which some may think important, doubtless exist. In like manner, a rapid survey may be taken of the animal kingdom.

First, the flesh of domestic quadrupeds: the ox and sheep, both adult and young; the pig; the horse and ass, chiefly in France. Milk, butter, and cheese in endless variety are derived chiefly from this group. More or less wild are the red deer, the fallow deer, and the roe deer. As game, the hare and rabbit; abroad, the bison, wild boar, bear, chamois, and kangaroo, are esteemed for food among civilized nations; but many other animals are eaten by half-civilized and savage peoples. All these are rich in nitrogen, fatty matters, and saline materials.

Among birds, we have domestic poultry in great variety of size and quality, with eggs in great abundance furnished chiefly by this class. All the wild fowl and aquatic birds; the pigeon tribe and the small birds. Winged game in all its well-known variety.

Of fish it is unnecessary to enumerate the enormous supply and the various species which exist everywhere, and especially on our own shores, from the sturgeon to whitebait, besides those in fresh-water rivers and lakes. All of them furnish nitrogenous matter largely, but, and particularly the white fish, possess fat in very small proportion, and little of saline materials. The salmon, mackerel, and herring tribes have more fat, the last-named in considerable quantity, forming a useful food well calculated to supplement cereal aliments, and largely adopted for the purpose both in the south and north of Europe.

The so-called reptiles furnish turtle, tortoise, and edible frog.

Among articulated animals are the lobsters, crabs, and shrimps. Among mollusks, the oyster and all the shellfish, which, as well as the preceding animals, in chemical composition closely resemble that of fish properly so called.

I shall not enter on a discussion of the question, Is man designed to be a vegetable feeder, or a flesh-eating or an omnivorous animal? Nor shall his teeth or other organs be examined in reference thereto. Any evidence to be found by anatomical investigation can only be safely regarded as showing what man is and has been. That he has been and is omnivorous to the extent of his means, there can exist no doubt. Whether he has been generally prudent or happy in his choice of food and drink is highly improbable, seeing that until very recently he has possessed no certain knowledge touching the relations which matters used as food hold with respect to the structure and wants of his body, and that such recent knowledge has been confined to a very few individuals. Whatever sound practice he may have attained, and it is not inconsiderable, in his choice and treatment of food, is the result of many centuries of empirical observation, the process of which has been attended with much disastrous failure and some damage to the experimenters. No doubt, much unsound constitution and proclivity to certain diseases result from the persistent use through many generations of improper food and drink.

Speaking in general terms, man seems, at the present time, prone to choose foods which are unnecessarily concentrated and too rich in nitrogenous or flesh-forming material, and to consume more in quantity than is necessary for the healthy performance of the animal functions. He is apt to leave out of sight the great difference, in relation to both quantity and quality of food, which different habits of life demand, e. g., between the habits of those who are chiefly sedentary and brain-workers and of those who are active and exercise muscle more than brain. He makes very small account of the different requirements by the child, the mature adult, and the declining or aged person. And he seems to be still less aware of the frequent existence of notable individual peculiarities in relation to the tolerance of certain aliments and drinks. As a rule, man has little knowledge of, or interest in, the processes by which food is prepared for the table, or the conditions necessary to the healthy digestion of it by himself. Until a tolerably high standard of civilization is reached, he cares more for quantity than quality, desires little variety, and regards as impertinent an innovation in the shape of a new aliment, expecting the same food at the same hour daily, his enjoyment of which apparently greatly depends on his ability to swallow the portion with extreme rapidity, that he may apply himself to some other and more important occupation without delay. Eating is treated, in fact, by multitudes much as they are disposed to treat religious duty—which eating assuredly is—that is, as a duty which is generally irksome, but unfortunately necessary to be

performed. As to any exercise of taste in the serving or in the combining of different foods at a meal, the subject is completely out of reach of the great majority of people, and is as little comprehended by them as the structure and harmonies of a symphony are by the first whistling boy one chances to meet in the street. The intelligent reader who has sufficient interest in this subject to have followed me thus far, may fancy this a sketch from savage life. On the contrary, I can assure him that ignorance and indifference to the nature and object of food mark the condition of a large majority of the so-called educated people of this country. Men even boast of their ignorance of so trivial a subject, regard it as unworthy the exercise of their powers, and—small compliment to their wives and sisters—fit only for the occupation of women.

Admitting man, then, to be physically so constituted as to be able to derive all that is necessary to the healthy performance of all his functions from the animal or from the vegetable kingdom, either singly or combined, he can scarcely be regarded otherwise than as qualified to be an omnivorous animal. Add to this fact his possession of an intelligence which enables him to obtain food of all kinds and climes, to investigate its qualities, and to render it more fit for digestion by heat—powers which no other animal possesses—and there appears no *a priori* reason for limiting his diet to products of either kingdom exclusively.

It is a matter of great interest to ascertain what have become, under the empirical conditions named, the staple foods of the common people of various climates and races—what, in short, supports the life and labor of the chief part of the world's population.

In the tropics and adjacent portions of the temperate zones, high temperature being incompatible with the physical activity familiar to northern races, a very little nitrogenous material suffices, since the waste of muscle is small. Only a moderate quantity of fat is taken, the demand for heat-production being inconsiderable. The chiefly starchy products supply nearly all the nutriment required, and such are found in rice, millet, etc. Rice by itself is the principal food of the wide zone thus indicated, including a large part of China, the East Indies, part of Africa and America, and also the West Indies. Small additions, where obtainable, are made of other seeds, of oil, butter, etc.; and, as temperature decreases by distance from the equator, some fish, fowl, or other light form of animal food, are added.

In the north of Africa, Arabia, and some neighboring parts, the date, which contains sugar in abundance, is largely eaten, as well as maize and other cereals.

Crossing to Europe, the southern Italian is found subsisting on macaroni, legumes, rice, fruits, and salads, with oil, cheese, fish, and small birds, but very little meat. More northward, besides fish and a little meat, maize is the chief aliment, rye and other cereals taking a

second place. The chestnut also is largely eaten by the poorer population, both it and maize containing more fatty matter than wheat, oats, and legumes.

In Spain, the inhabitants subsist chiefly on maize and rice, with some wheat and legumes, among them the garbanzo or "chick pea," and one of the principal vegetable components of the national *olla*, which contains also a considerable proportion of animal food in variety, as bacon, sausage, fowl, etc. Fruit is fine and abundant; especially so are grapes, figs, and melons. There is little or no butter, the universal substitute for which is olive-oil, produced in great quantity. Fowls and the pig furnish the chief animal food, and garlic is the favorite condiment.

Going northward, flesh of all kinds occupies a more considerable place in the dietary. In France the garden vegetables and legumes form an important staple of diet for all classes; but the very numerous small land proprietors subsist largely on the direct products of the soil, adding little more than milk, poultry, and eggs, the produce of their small farms. The national *pot-au-feu* is an admirable mixed dish, in which a small portion of meat is made to yield all its nutritive qualities, and to go far in mingling its odor and savor with those of the fragrant vegetables which are so largely added to the stock. The stock-meat eaten hot, or often cold with plenty of green salad and oil, doubtless the most palatable mode of serving it, thus affords a source of fat, if not otherwise provided for by butter, cheese, etc.

Throughout the German Empire, the cereals, legumes, greens, roots, and fruits supply an important proportion of the food consumed by the common population. Wheaten bread chiefly, and some made from rye, also beans and peas, are used abundantly. Potatoes and green vegetables of all kinds are served in numerous ways, but largely in soups, a favorite dish. Meats, chiefly pork, are greatly esteemed in the form of sausage, and appear also as small portions or joints, but freely garnished with vegetables, on the tables of those who can afford animal diet. Going northward, where the climate is no longer adapted for the production of wheat, as in parts of Russia, rye and oats form the staple food from the vegetable kingdom, associated with an increased quantity of meat and fatty materials.

Lastly, it is well known that the inhabitants of the Arctic zone are compelled to consume large quantities of oily matter, in order to generate heat abundantly; and also that animal food is necessarily the staple of their dietary. Vegetables, which, moreover, are not producible in so severe a climate, would there be wholly inadequate to support life.

We will now consider the food which the English peasant and artisan provide. The former lives, for the most part, on wheaten bread and cheese, with occasionally a little bacon, some potatoes, and perhaps garden greens: it is rarely indeed that he can obtain flesh. To

this dietary the artisan adds meat, mostly beef or mutton, and some butter. A piece of fresh and therefore not tender beef is baked, or cooked in a frying-pan, in the latter case becoming a hard, indigestible, and wasted morsel; by the former process a somewhat better dish is produced, the meat being usually surrounded by potatoes or by a layer of some batter, since both contain starchy products and absorb the fat which leaves the meat. The food of the peasant might, however, be cheaper and better; while the provision of the artisan is simply extravagant and bad. At this period of our national history, when food is scarce, and the supply of meat insufficient to meet the demand which our national habits of feeding perpetuate, it is an object of the first importance to consider whether other aliments can be obtained at a cheaper rate, and at the same time equal in quality to those of the existing dietary. Many believe that this object may be accomplished without difficulty, and that the chief obstacle to improvement in the food supply, not only of the classes referred to, but in that of the English table generally, is the common prejudice which exists against any aliment not yet widely known or tried. The one idea which the working classes possess in relation to improvement in diet, and which they invariably realize when wages are high, is the inordinate use of butcher's meat. To make this the chief element of at least three meals daily, and to despise bread and vegetables, is for them no less a sign of taste than a declaration of belief in the perfection of such food for the purposes of nutrition.

We have already seen that not only can all that is necessary to the human body be supplied by the vegetable kingdom solely, but that, as a matter of fact, the world's population is to a large extent supported by vegetable products. Such form, at all events, the most wholesome and agreeable diet for the inhabitants of the tropics. Between about forty and nearly sixty degrees of latitude we find large populations of fine races trained to be the best laborers in the world on little more than cereals and legumes, with milk (cheese and butter), as food; that little consisting of irregular and scanty supplies of fish, flesh, and fatty matter. In colder regions vegetable products are hardly to be obtained, and flesh and fat are indispensable. Thus man is clearly omnivorous; while *men* may be advantageously vegetarian in one climate, mixed eaters in another, and exclusively flesh-eaters in a third.

I have not hesitated to say that Englishmen generally have adopted a diet adapted for a somewhat more northerly latitude than that which they occupy; that the cost of their food is therefore far greater than it need be, and that much of their peculiar forms of indigestion and resulting chronic disease is another necessary consequence of the same error. They consume too much animal food, particularly the flesh of cattle. For all who are occupied with severe and continuous mechanical labor, a mixed diet, of which cereals and legumes form a large portion, and meat, fish, eggs, and milk form a

moderate proportion, is more nutritious and wholesome than chiefly animal food. For those whose labor is chiefly mental, and whose muscular exercise is inconsiderable, still less of concentrated nitrogenous food is desirable. A liberal supply of cereals and legumes, with fish, and flesh in its lighter forms, will better sustain such activity than large portions of butcher's meat twice or thrice a day. Then again it is absolutely certain, contrary to the popular belief as this is, that while a good supply of food is essential during the period of growth and active middle life, a diminished supply is no less essential to health and prolongation of life during declining years, when physical exertion is small, and the digestive faculty sometimes becomes less powerful also. I shall not regard it as within my province here to dilate on this topic, but shall assert that the "supporting" of aged persons, as it is termed, with increased quantities of food and stimulant, is an error of cardinal importance. These things being so, a consideration of no small concern arises in relation to the economical management of the national resources. For it is a fair computation that every acre of land devoted to the production of meat is capable of becoming the source of three or four times the amount of produce of equivalent value as food, if devoted to the production of grain. In other words, a given area of land cropped with cereals and legumes will support a population more than three times as numerous as that which can be sustained on the same land devoted to the growth of cattle. Moreover, the corn-land will produce, almost without extra cost, a considerable quantity of animal food, in the form of pigs and poultry, from the offal or coarser parts of vegetable produce which is unsuitable for human consumption.

Thus this country purchases every year a large and increasing quantity of corn and flour from foreign countries, while more of our own land is yearly devoted to grazing purposes. The value of corn and flour imported by Great Britain in 1877 was no less than £63,536,322, while in 1875 it was only just over £53,000,000. The increased import during the last thirty-two years is well exhibited in the following extract: "In 1846 the imports of corn and flour amounted to seventeen pounds weight per head of population; in 1855 they had risen to seventy pounds per head; and in 1865 to ninety-three pounds weight per head of population. Finally, in 1877 the imports of corn and flour amounted to one hundred and seventy pounds weight per head of population of the United Kingdom." *

Lastly, those who are interested in the national supply of food must lament that, while Great Britain possesses perhaps the best opportunities in the world for securing a large and cheap supply of fish, she fails to attain it, and procures so little only that it is to the great majority of the inhabitants an expensive luxury. Fish is a food of great value; nevertheless, it ought in this country to be one of the

* "Statesman's Year Book," 1879, p. 258.

cheapest aliments, since production and growth cost absolutely nothing, only the expenses of catching and of a short transport being incurred.

Having enunciated some general principles which it is important should first be established, I shall offer briefly an illustration or two of the manner in which they may be applied. This brings us to the second division of the subject, viz., the practical treatment of certain aliments in order to render them suitable for food. Dealing first with that of the agricultural laborer, our object is to economize his small pittance, to give him, if possible, a rather more nutritive, wholesome, and agreeable dish—he can have but one—that his means have hitherto furnished. But here there is little scope for change; already said to live chiefly on bread and cheese, with occasionally bacon, two indications only for improvement can be followed, viz., augmentation of nitrogenous matter to meet the wear and tear of the body in daily hard labor, and of fatty matter to furnish heat and force. A fair proportion of meat, one of the best means of fulfilling them, is not within his reach. First, his daily bread ought to contain all the constituents of the wheat, instead of being made of flour from which most of the mineral elements have been removed. But beans and peas are richer in nitrogen than wheat, and equal it in starch, mineral matters, and fat, the last being in very small quantity, while maize has three times their proportion of fat. Hence all of these would be useful additions to his dietary, being cheaper than wheat in the market, although, the retail demand being at present small, they may not be so in the small shops. As an illustration of the value of legumes combined with fat, it may be remembered how well the Erbswurst supported the work of the German armies during the winter of 1870–'71, an instructive lesson for us in England at the present moment. It consists of a simple pea-soup mixed with a certain proportion of bacon or lard, and dried so as to be portable, constituting in very small compass a perfect food, especially suitable for supporting muscular expenditure and exposure to cold. Better than any flesh, certainly any which could be transported with ease, the cost was not more than half that of ordinary meat. It was better also, because the form of the food is one in which it is readily accessible and easily digested; it was relished cold, or could be converted in a few minutes into good soup with boiling water. But for our laborer probably the best of the legumes is the haricot bean, red or white, the dried mature bean of the plant whose pods we eat in the early green state as "French beans." For this purpose they may be treated thus: Soak, say, a quart of the dried haricots in cold water for about twelve hours, after which place them in a saucepan, with two quarts of cold water and a little salt, on the fire; when boiling remove to the corner and simmer slowly until the beans are tender; the time required being about two to three hours. This quantity will fill a large dish, and may be

eaten with salt and pepper. It will be greatly improved at small cost by the addition of a bit of butter, or of melted butter with parsley, or if an onion or two have been sliced and stewed with the haricots. A better dish still may be made by putting all, or part, after boiling, into a shallow frying-pan and lightly frying for a few minutes with a little lard and some sliced onions. With a few slices of bacon added, a comparatively luxurious and highly nutritive meal may be made. But there is still in the saucepan, after boiling, a residue of value, which the French peasant's wife, who turns everything to account, utilizes in a manner quite incomprehensible to the Englishwoman. The water in which dried haricots have stewed, and also that in which green French beans have been boiled, contain a proportion of nutritious matter. The Frenchwoman always preserves this liquor carefully, cuts and fries some onions, adds these and some thick slices of bread, a little salt and pepper with a pot-herb or two from the corner of the garden, and thus serves hot an agreeable and useful *croûte au pot.* It ought to be added that the haricots so largely used by the working classes throughout Europe are not precisely either "red" or "white," but some cheaper local varieties, known as *haricots du pays.* These, I am assured on good authority, could be supplied here at about twopence a pound, their quality as food being not inferior to other kinds.

But haricots—let them be the fine white Soissons—are good enough to be welcome at any table. A roast leg or shoulder of mutton should be garnished by a pint boiled as just directed, lying in the gravy of the dish; and some persons think that, with a good supply of the meat gravy, and a little salt and pepper, "the haricots are by no means the worst part of the mutton." Then with a smooth *purée* of mild onions, which have been previously sliced, fried brown, and stewed, served freely as sauce, our leg of mutton and haricots become the *gigot à la bretonne* well known to all lovers of wholesome and savory cookery. Next, white haricots stewed until soft, made into a rather thick *purée,* delicately flavored by adding a small portion of white *purée* of onions (not browned by frying as in the preceding sauce), produce an admirable garnish for the center of a dish of small cutlets, or an *entrée* of fowl, etc. Again, the same haricot *purée* blended with a veal stock, well flavored with fresh vegetables, furnishes an admirable and nutritious white soup. The red haricots in like manner with a beef stock make a superlative brown soup, which, with the addition of portions of game, especially of hare, forms, for those who do not despise economy in *cuisine* where the result attained is excellent, a soup which in texture and in flavor would by many persons not be distinguishable from a common *purée* of game itself. Stewed haricots also furnish, when cold, an admirable salad, improved by adding slices of tomato, etc., the oil supplying the one element in which the bean is deficient; and a perfectly nutritious food is produced for those who can digest it.

—and they are numerous—in this form. The same principle, it may be observed, has, although empirically, produced the well-known dishes of beans and bacon, ham and green peas, boiled pork and pease-pudding, all of them old and popular but scientific combinations. Thus also the French, serving *petits pois* as a separate dish, add butter freely and a dash of sugar, the former making the compound physiologically complete, the latter agreeably heightening the natural sweetness of the vegetable.

Let me recall, at the close of these few hints about the haricot, the fact that there is no product of the vegetable kingdom so nutritious; holding its own in this respect, as it well can, even against the beef and mutton of the animal kingdom. The haricot ranks just above lentils, which have been so much praised of late, and rightly, the haricot being also to most palates more agreeable. By most stomachs, too, haricots are more easily digested than meat is; and, consuming weight for weight, the eater feels lighter and less oppressed, as a rule, after the leguminous dish; while the comparative cost is very greatly in favor of the latter. I do not of course overlook in the dish of simple haricots the absence of savory odors proper to well-cooked meat; but nothing is easier than to combine one part of meat with two parts of haricots, adding vegetables and garden herbs, so as to produce a stew which shall be more nutritious, wholesome, and palatable than a stew of all meat with vegetables, and no haricots. Moreover, the cost of the latter will be more than double that of the former.

I have just adverted to the bread of the laborer, and recommended that it should be made from entire wheat meal; but it should not be so coarsely ground as that commonly sold in London as "whole meal." The coarseness of "whole meal" is a condition designed to exert a specific effect on the digestion for those who need it, and, useful as it is in its place, is not desirable for the average population referred to. It is worth observing, in relation to this coarse meal, that it will not produce light agreeable bread in the form of loaves: they usually have either hard, flinty crusts, or soft, dough-like interiors; but the following treatment, after a trial or two, will be found to produce excellent and most palatable bread: To two pounds of whole meal add half a pound of fine flour and a sufficient quantity of baking-powder and salt; when these are well mixed, rub in about two ounces of butter, and make into dough with half milk and water, or with all milk if preferred. Make rapidly into flat cakes like "tea-cakes," and bake in a quick oven, leaving them afterward to finish thoroughly at a lower temperature. The butter and milk supply fatty matter in which the wheat is somewhat deficient; all the saline and mineral matters of the husk are retained; and thus a more nutritive form of bread can not be made. Moreover, it retains the natural flavor of the wheat, in place of the insipidity which is characteristic of fine flour, although it is indisputable that bread produced from the latter, especially at Paris and

Vienna, is unrivaled for delicacy, texture, and color. Whole meal may be bought; but mills are now cheaply made for home use, and wheat may be ground to any degree of coarseness desired.

Here illustration by recipe must cease; although it would be an easy task to fill a volume with matter of this kind, illustrating the ample means which exist for diminishing somewhat the present wasteful use of "butcher's meats" with positive advantage to the consumer. Many facts in support of this position will appear as we proceed. But another important object in furnishing the foregoing details is to point out how combinations of the nitrogenous, starchy, fatty, and mineral elements may be made, in well-proportioned mixtures, so as to produce what I have termed a "perfect" dish—perfect, that is, so far as the chief indication is concerned, viz., one which supplies every demand of the body, without containing any one element in undue proportion. For it is obvious that one or two of these elements may exist in injurious excess, especially for delicate stomachs, the varied peculiarities of which, as before insisted on, must sometimes render necessary a modification of all rules. Thus it is easy to make the fatty constituent too large, and thereby derange digestion, a result frequently experienced by persons of sedentary habits, to whom a little pastry, a morsel of *foie gras*, or a rich cream is a source of great discomfort, or of a "bilious attack"; while the laborer, who requires much fatty fuel for his work, would have no difficulty in consuming a large quantity of such compounds with advantage. Nitrogenous matter also is commonly supplied beyond the eater's wants; and, if more is consumed than can be used for the purposes which such aliment subserves, it must be eliminated in some way from the system. This process of elimination, it suffices to say here, is undoubtedly a prolific cause of disease, such as gout and its allies, as well as other affections of a serious character, which would in all probability exist to a very small extent, were it not the habit of those who, being able to obtain the strong or butcher's meats, eat them daily year after year, in larger quantity than the constitution can assimilate.

Quitting the subject of wheat and the leguminous seeds, it will be interesting to review briefly the combinations of rice, which furnishes so large a portion of the world with a vegetable staple of diet. Remembering that it contains chiefly starch, with nitrogen in small proportion, and almost no fat or mineral elements, and just sufficing perhaps to meet the wants of an inactive population in a tropical climate, the first addition necessary for people beyond this limit will be fat, and, after that, more nitrogen. Hence the first effort to make a dish of rice "complete" is the addition of butter and a little Parmesan cheese, in the simple *risotto*, from which, as a starting-point, improvement, both for nutritive purposes and for the demands of the palate, may be carried to any extent. Fresh additions are made in the shape of marrow, of morsels of liver, etc., of meat broth with onion and spice,

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which constitute the mixture, when well prepared, nutritious and highly agreeable. The analogue of this mainly Italian dish is the *pilau* or *pilaff* of the Orientals, consisting as it does of nearly the same materials, but differently arranged. The curry of poultry and the kedgeree of fish are further varieties which it is unnecessary to describe. Follow the same combination to Spain, where we find a popular national dish, but slightly differing from the foregoing, in the *pollo con arroz*, which consists of abundance of rice, steeped in a little broth and containing morsels of fowl, bacon, and sausage, with appetizing spices, and sufficing for an excellent meal.

Another farinaceous product of world-wide use is the maize or Indian corn. With a fair amount of nitrogen, starch, and mineral elements, it contains also a good proportion of fat, and is made into bread, cakes, and puddings of various kinds. It is complete, but susceptible of improvement by the addition of nitrogen. Hence, in the United States, where it is largely used, it is often eaten with beans under the name of "succotash." In Italy it is ground into the beautiful yellow flour which is conspicuous in the streets of almost every town; when made into a firm paste by boiling in water, and sprinkled with Parmesan cheese, a nitrogenous aliment, it becomes what is known as *polenta*, and is largely consumed with some relish in the shape of fried fish, sardines, sausage, little birds, or morsels of fowl or goose, by which, of course, fresh nitrogen is added. Macaroni has been already alluded to; although rich in nitrogenous and starchy materials, it is deficient in fat. Hence it is boiled and eaten with butter and parmesan (*à l'italienne*) and with tomatoes, which furnish saline matters, with meat gravy, or with milk.

Nearer home the potato forms a vegetable basis in composition closely resembling rice, and requiring therefore additions of nitrogenous and fatty elements. The Irishman's inseparable ally, the pig, is the natural, and to him necessary, complement of the tuber, making the latter a complete and palatable dish. The every-day combination of mashed potato and sausage is an application of the same principle. In the absence of pork, the potato-eater substitutes a cheap oily fish, the herring. The combination of fatty material with the potato is still further illustrated in our baked potato and butter, in fried potatoes in their endless variety of form, in potato mashed with milk or cream, served in the ordinary way with *maître d'hôtel* butter, or arriving at the most perfect and finished form in the *pommes de terre sautées au beurre* of a first-class French restaurant, where it becomes almost a *plat de luxe*. Even the simple bread and butter or bread and cheese of our own country equally owe their form and popularity to physiological necessity; the deficient fat of the bread being supplemented by the fatty elements of each addition, the cheese supplying also its proportion of nitrogenous matter, which exists so largely in its peculiar principle caseine. So, again, all the suet-puddings, "short-

cake," pie-crust, or pastry, whether baked or boiled, consist simply of farinaceous food rendered stronger nutriment by the addition of fatty matter.

In the same way almost every national dish might be analyzed up to the *pot-au-feu* of our neighbors, the right management of which combines nutritious quality with the abundant aroma and flavor of fresh vegetables which enter so largely into this economical and excellent mess.

It will be apparent that, up to this point, our estimate of the value of these combinations has been limited, or almost so, by their physiological completeness as foods, and by their economical value in relation to the resources of that great majority of all populations, which is poor. But when the inexorable necessity for duly considering economy has been complied with, the next aim is to render food as easily digestible as possible, and agreeable to the senses of taste, smell, and sight.

The hard laborer with simple diet, provided his aliment is complete and fairly well cooked, will suffer little from indigestion. He can not be guilty, for want of means, of eating too much, fertile source of deranged stomach with those who have the means; physical labor being also in many circumstances the best preventive of dyspepsia. "Live on sixpence a day and earn it," attributed to Abernethy as the sum of his dietary for a gluttonous eater, is a maxim of value, proved by millions. But for the numerous sedentary workers in shops, offices, in business and professions of all kinds, the dish must not only be "complete"; it must be so prepared as to be easily digestible by most stomachs of moderate power, and it should also be as appetizing and agreeable as circumstances admit.

On questioning the average middle-class Englishman as to the nature of his food, the all but universal answer is, "My living is plain, always roast and boiled"—words which but too clearly indicate the dreary monotony, not to say unwholesomeness, of his daily food; while they furthermore express his satisfaction, such as it is, that he is no luxurious feeder, and that, in his opinion, he has no right to an indigestion. Joints of beef and mutton, of which we all know the very shape and changeless odors, follow each other with unvarying precision, six roast to one boiled, and have done so ever since he began to keep house some five-and-twenty years ago! I am not sanguine enough to suppose that this unbroken order which rules the dietary of the great majority of British families of moderate and even of ample means will be disturbed by any suggestions of mine. Nevertheless, in some younger households, where habits followed for want of thought or knowledge have not yet hardened into law, there may be a disposition to adopt a healthier diet and a more grateful variety of aliment. For variety is not to be obtained in the search for new animal food. Often as the lament is heard that some new meat is not

discovered, that the butcher's display of joints offers so small a range for choice, it is not from that source that wholesome and pleasing additions to the table will be obtained.

But our most respectable paterfamilias, addicted to "plain living," might be surprised to learn that the vaunted "roasting" has no longer in his household the same significance it had five-and-twenty years ago; and that probably, during the latter half of that term, he has eaten no roast meat, whatever he may aver to the contrary. Baking, at best in a half-ventilated oven, has long usurped the function of the spit in most houses, thanks to the ingenuity of economical range-makers. And the joint, which formerly turned in a current of fresh air before a well-made fire, is now half stifled in a close atmosphere of its own vapors, very much to the destruction of the characteristic flavor of a roast. This is a smaller defect, however, as regards our present object than that which is involved by the neglect in this country of braising as a mode of cooking animal food. By this process more than mere "stewing" is of course intended. In braising, the meat is just covered with a strong liquor of vegetable and animal juices (*braise* or *mirepoix*) in a closely covered vessel, from which as little evaporation as possible is permitted, and is exposed for a considerable time to a surrounding heat just short of boiling. By this treatment tough, fibrous flesh, whether of poultry or of cattle, or meat unduly fresh, such as can alone be procured during the summer season in towns, is made tender, and is furthermore impregnated with the odors and flavor of fresh vegetables and sweet herbs. Thus, also, meats which are dry, or of little flavor, as veal, become saturated with juices and combined with sapid substances, which render the food succulent and delicious to the palate. Small portions sufficing for a single meal, however small the family, can be so dealt with; and a *réchauffée*, or cold meat for to-morrow, is not a thing of necessity, but only of choice when preferred. Neither time nor space permits me to dwell further on this topic, the object of this paper being rather to furnish suggestions than explicit instruction in detail.

The art of frying is little understood, and the omelet is almost entirely neglected by our countrymen. The products of our frying-pan are often greasy, and therefore for many persons indigestible, the shallow form of the pan being unsuited for the process of boiling in oil, that is, at a heat of nearly 500° Fahr., that of boiling water being 212°. This high temperature produces results which are equivalent indeed to quick roasting, when the article to be cooked is immersed in the boiling fat. Frying, as generally conducted, is rather a combination of broiling, toasting, or scorching; and the use of the deep pan of boiling oil or dripping, which is essential to the right performance of the process, and especially preventing greasiness, is a rare exception and not the rule in ordinary kitchens. Moreover, few English cooks can make a tolerable omelet; and thus one of the most delicious and

nutritious products of culinary art, with the further merit that it can be more rapidly prepared than any other dish, must really at present be regarded as an exotic. Competent instruction at first and a little practice are required, in order to attain a mastery in producing an omelet; but, these given, there is no difficulty in turning out a first-rate specimen. The ability to do this may be so useful in the varied circumstances of travel, etc., that no young man destined for foreign service, or even who lives in chambers, should fail to attain the easily acquired art.—*Nineteenth Century.*

JULIUS ROBERT MAYER.

THE name of the remarkable man whose likeness we give in this number of the "Monthly" is now intimately and imperishably associated with the establishment of the most important scientific truth that has been developed during the last hundred years—the "Conservation of Energy." It is a truth belonging exclusively to no one man, and to no one nation, but to an epoch of scientific advancement that was made by the labors of many distinguished investigators working independently of each other in different countries. In such circumstances it is easy to fall into error in estimating the merits of alleged discoverers. In the first place, there may be very great differences in the positions of men as respects favorable opportunities of making their work known. There is besides less familiarity with what is going on in foreign countries than near by; and there is, moreover, the warping influence of national prejudice by which the claims of men are liable to be exaggerated at home and depreciated abroad. There is undoubtedly less of this bias in science than in any other sphere of intellectual exertion, but this sphere is by no means free from it. It was the fortune of Mayer to suffer from all these causes, and to such a degree that his character as an original discoverer has been denied on very high authority. The ground was strenuously maintained that he had no right whatever to a place among the founders of the great modern doctrine of the "Correlation of Forces." This denial led to investigation and sharp controversy, the result of which was not only to vindicate his claims to be ranked among the discoverers of the new principle, but it was shown that he was probably ahead of all others in grasping and developing it. Now that he has passed away, it is proper to review the subject, which may prove instructive as a chapter of scientific history, as well as interesting in its personal bearing. As we find the investigation thoroughly worked out and most admirably presented in the searching controversy which has now become memorable in the annals of discovery, we shall quote

freely from the materials before us so as to present to our readers as faithfully as possible the considerations on the strength of which the claims of Mayer first became recognized.

As regards the life of Mayer the details are meager. He was born in Heilbronn, Würtemberg, November 25, 1814. He received his early education in the gymnasium of his native town, and studied medicine at Tubingen, finishing his course in Munich and Paris. In 1840 he made a voyage on a Dutch freighter to Java, and spent the summer of that year in professional practice at Batavia. Returning to Heilbronn he first became county wound-physician, and afterward physician to the city, and while giving the main portion of his time to professional labors he devoted himself systematically, and with great assiduity, to original scientific researches on the wide subject of the "Conservation of Forces." In the revolution of 1848 Dr. Mayer took what was called the side of order, which roused against him the antagonism of many of his neighbors. He believed that he had made very important discoveries which were unrecognized and were ascribed to others, while his scientific works were attacked and discredited in a way that preyed upon his feelings and disturbed his mind. This was aggravated by the loss of his children, and he fell into an excited and sleepless condition. Being suddenly seized with a fit of delirium on May 28, 1850, he quitted his bed and leaped from a second-story window, thirty feet high, to the street below. He recovered from the shock, but his mind was so seriously affected that he was sent to a lunatic asylum. Dr. Mülburger, physician to the institution, states that the equilibrium of his mental and emotional nature was seriously affected, one of the symptoms being that, "if you conversed with him about a scientific topic, it was very hard to keep him to the point: his ideas were profound, it is true, surprisingly so, but they came disconnected; they went to the heart of the subject, but they did not hold on to it. He was subject to occasional fits of uncontrollable rage, and on feeling them coming on he would ask to be put in one of the strong cells of the asylum. These fits came on only three or four times during the four months he spent at the asylum, and they did not last long. He had a very strong thirst for spirituous liquors, an inclination which was the result of his mental malady, and the gratification of which increased it." He was at length restored to health, and busied himself with grape culture at Heilbronn. He died in his native town on March 20, 1878, aged sixty-three years.

The following lucid account of Mayer's labors and judicial estimate of his position were made by Professor Tyndall in 1871, and are so admirable that we quote them in full, in preference to anything that it would be possible for us to write:

Dr. Julius Robert Mayer was educated for the medical profession. In the summer of 1840, as he himself informs us, he was at Java, and there observed that the venous blood of some of his patients had a singularly bright red color.

The observation riveted his attention; he reasoned upon it, and came to the conclusion that the brightness of the color was due to the fact that a less amount of oxidation sufficed to keep up the temperature of the body in a hot climate than in a cold one. The darkness of the venous blood he regarded as the visible sign of the energy of the oxidation.

It would be trivial to remark that accidents such as this, appealing to minds prepared for them, have often led to great discoveries. Mayer's attention was thereby drawn to the whole question of animal heat. Lavoisier had ascribed this heat to the oxidation of the food. "One great principle," says Mayer, "of the physiological theory of combustion is, that under all circumstances the same amount of fuel yields, by its perfect combustion, the same amount of heat; that this law holds good even for vital processes; and that hence the living body, notwithstanding all its enigmas and wonders, is incompetent to generate heat out of nothing."

But beyond the power of generating internal heat, the animal organism can also generate heat outside of itself. A blacksmith, for example, by hammering can heat a nail, and a savage by friction can warm wood to its point of ignition. Now, unless we give up the physiological axiom that the living body can not create heat out of nothing, "we are driven," says Mayer, "to the conclusion that it is the *total* heat generated within and *without* that is to be regarded as the true calorific effect of the matter oxidized in the body."

From this, again, he inferred that the heat generated externally must stand in a fixed relation to the work expended in its production. For, supposing the organic processes to remain the same, if it were possible, by the mere alteration of the apparatus, to generate different amounts of heat by the same amount of work, it would follow that the oxidation of the same amount of material would sometimes yield a less, sometimes a greater, quantity of heat. "Hence," says Mayer, "that a fixed relation subsists between heat and work, is a postulate of the physiological theory of combustion."

This is the simple and natural account, given subsequently by Mayer himself, of the course of thought started by his observation in Java. But the conviction once formed, that an unalterable relation subsists between work and heat, it was inevitable that Mayer should seek to express it numerically. It was also inevitable that a mind like his, having raised itself to clearness on this important point, should push forward to consider the relationship of natural forces generally. At the beginning of 1842 his work had made considerable progress; but he had become physician to the town of Heilbronn, and the duties of his profession limited the time which he could devote to purely scientific inquiry. He thought it wise, therefore, to secure himself against accident, and in the spring of 1842 wrote to Liebig, asking him to publish in his "Annalen" a brief preliminary notice of the work then accomplished. Liebig did so, and Dr. Mayer's first paper is contained in the May number of the "Annalen" for 1842.

Mayer had reached his conclusions by reflecting on the complex processes of the living body; but his first step in public was to state definitely the physical principles on which his physiological deductions were to rest. He begins, therefore, with the forces of inorganic nature. He finds in the universe two systems of causes which are not mutually convertible: the different kinds of matter and the different forms of force. The first quality of both he affirms to be *indestructibility*. A force can not become nothing, nor can it arise from nothing. Forces are convertible, but not destructible. In the terminology of his time, he then gives clear expression to the ideas of potential and dynamic energy, illus-

trating his point by a weight resting upon the earth, suspended at a height above the earth, and actually falling to the earth. He next fixes his attention on cases where motion is apparently destroyed, without producing other motion; on the shock of inelastic bodies, for example. Under what form does the vanished motion maintain itself? "Experiment alone," says Mayer, "can help us here." He warms water by stirring it; he refers to the force expended in overcoming friction. Motion in both cases disappears; but heat is generated, and the quantity generated is the equivalent of the motion destroyed. "Our locomotives," he observes with extraordinary sagacity, "may be compared to distilling apparatus: the heat beneath the boiler passes into the motion of the train, and is again deposited as heat in the axles and wheels."

A numerical solution of the relation between heat and work was what Mayer aimed at, and toward the end of his first paper he makes the attempt. It was known that a definite amount of air, in rising one degree in temperature, can take up two different amounts of heat. If its volume be kept constant, it takes up one amount; if its pressure be kept constant, it takes up a different amount. These two amounts are called the specific heat under constant volume and under constant pressure. The ratio of the first to the second is as 1 : 1·421. No man, to my knowledge, prior to Dr. Mayer, penetrated the significance of these two numbers. He first saw that the excess 0·421 was not, as then universally supposed, heat actually lodged in the gas, but heat which had been actually consumed by the gas in expanding against pressure. The amount of work here performed was accurately known, the amount of heat consumed was also accurately known, and from these data Mayer determined the mechanical equivalent of heat. Even in this first paper he is able to direct attention to the enormous discrepancy between the theoretic power of the fuel consumed in steam-engines and their useful effect.

Though this paper contains but the germ of his further labors, I think it may be safely assumed that, as regards the mechanical theory of heat, this obscure Heilbronn physician, in the year 1842, was in advance of all the scientific men of the time.

Having, by the publication of this paper, secured himself against what he calls "Eventualitäten," he devoted every hour of his spare time to his studies, and in 1845 published a memoir which far transcends his first one in weight and fullness, and indeed marks an epoch in the history of science. The title of Mayer's first paper was, "Remarks on the Forces of Inorganic Nature."* The title of his second great essay was, "Organic Motion in its Connection with Nutrition." In it he expands and illustrates the physical principles laid down in his first brief paper. He goes fully through the calculation of the mechanical equivalent of heat. He calculates the performances of steam-engines, and finds that 100 pounds of coal, in a good working engine, produce only the same amount of heat as 95 pounds in an unworking one; the 5 missing pounds having been converted into work. He determines the useful effect of gunpowder, and finds nine per cent. of the force of the consumed charcoal invested on the moving ball. He records observations on the heat generated in water agitated by the pulping-engine of a paper manufactory, and calculates the equivalent of that heat in horse-power. He compares chemical combination with mechanical combination —the union of atoms with the union of falling bodies with the earth. He calculates the velocity with which a body starting at an infinite distance would

* Translations of this and other important papers of Mayer are contained in the volume on the "Correlation of Forces," published by D. Appleton & Co., New York.

strike the earth's surface, and finds that the heat generated by its collision would raise an equal weight of water 17,356° C. in temperature. He then determines the thermal effect which would be produced by the earth itself falling into the sun. So that here, in 1845, we have the germ of that meteoric theory of the sun's heat which Mayer developed with such extraordinary ability three years afterward. He also points to the almost exclusive efficacy of the sun's heat in producing mechanical motions upon the earth, winding up with the profound remark that the heat developed by friction in the wheels of our wind- and water-mills comes from the sun in the form of vibratory motion; while the heat produced by mills driven by tidal action is generated at the expense of the earth's axial rotation.

Having thus, with firm step, passed through the powers of inorganic nature, his next object is to bring his principles to bear upon the phenomena of vegetable and animal life. Wood and coal can burn; whence come their heat, and the work producible by that heat? From the immeasurable reservoir of the sun. Nature has proposed to herself the task of storing up the light which streams earthward from the sun, and of casting into a permanent form the most fugitive of all powers. To this end she has overspread the earth with organisms which, while living, take in the solar light, and by its consumption generate forces of another kind. These organisms are plants. The vegetable world, indeed, constitutes the instrument whereby the wave-motion of the sun is changed into the rigid form of chemical tension, and thus prepared for future use. With this prevision, as will subsequently be shown, the existence of the human race itself is inseparably connected. It is to be observed that Mayer's utterances are far from being anticipated by vague statements regarding the "stimulus" of light, or regarding coal as "bottled sunlight." He first saw the full meaning of De Saussure's observation as to the reducing power of the solar rays, and gave that observation its proper place in the doctrine of conservation. In the leaves of a tree, the carbon and oxygen of carbonic acid, and the hydrogen and oxygen of water, are forced asunder at the expense of the sun, and the amount of power thus sacrificed is accurately restored by the combustion of the tree. The heat and work potential in our coal strata are so much strength withdrawn from the sun of former ages. Mayer lays the axe to the root of the notions regarding "vital force" which were prevalent when he wrote. With the plain fact before us that in the absence of the solar rays plants can not perform the work of reduction, or generate chemical tensions, "it is," he contends, "incredible that these tensions should be caused by the mystic play of the vital force." Such an hypothesis would cut off all investigation; it would land us in a chaos of unbridled phantasy. "I count," he says, "therefore, upon your agreement with me when I state, as an axiomatic truth, that during vital processes the *conversion* only, and never the *creation* of matter or force, occurs."

Having cleared his way through the vegetable world, as he had previously done through inorganic nature, Mayer passes on to the other organic kingdom. The physical forces collected by plants become the property of animals. Animals consume vegetables, and cause them to reunite with the atmospheric oxygen. Animal heat is thus produced; and not only animal heat, but animal motion. There is no indistinctness about Mayer here; he grasps his subject in all its details, and reduces to figures the concomitants of muscular action. A bowler who imparts to an eight-pound ball a velocity of thirty feet, consumes in the act one-tenth of a grain of carbon. A man weighing 150 pounds, who lifts his own body to a height of eight feet, consumes in the act one grain of

carbon. In climbing a mountain 10,000 feet high, the consumption of the same man would be two ounces, four drachms, fifty grains of carbon. Boussingault had determined experimentally the addition to be made to the food of horses when actively working, and Liebig had determined the addition to be made to the food of men. Employing the mechanical equivalent of heat, which he had previously calculated, Mayer proves the additional food to be amply sufficient to cover the increased oxidation.

But he does not content himself with showing, in a general way, that the human body burns according to definite laws, when it performs mechanical work. He seeks to determine the particular portion of the body consumed, and in doing so executes some noteworthy calculations. The muscles of a laborer 150 pounds in weight weigh 64 pounds; but, when perfectly desiccated, they fall to 15 pounds. Were the oxidation corresponding to that laborer's work exerted on the muscles alone, they would be utterly consumed in eighty days. The heart furnishes a still more striking example. Were the oxidation necessary to sustain the heart's action exerted upon its own tissue, it would be utterly consumed in eight days. And, if we confine our attention to the two ventricles, their action would be sufficient to consume the associated muscular tissue in three and a half days. Here, in his own words, emphasized in his own way, is Mayer's pregnant conclusion from these calculations: "The muscle is only the apparatus by means of which the conversion of the force is effected; *but it is not the substance consumed in the production of the mechanical effect.*" He calls the blood "the oil of the lamp of life"; it is the slow-burning fluid whose chemical force, in the furnace of the capillaries, is sacrificed to produce animal motion. This was Mayer's conclusion twenty-six years ago. It was in complete opposition to the scientific conclusions of his time; but eminent investigators have since amply verified it.

Thus, in baldest outline, I have sought to give some notion of the first half of this marvelous essay. The second half is so exclusively physiological that I do not wish to meddle with it. I will only add the illustration employed by Mayer to explain the action of the nerves upon the muscles. As an engineer, by the motion of his finger in opening a valve or loosing a detent, can liberate an amount of mechanical motion almost infinite compared with its exciting cause, so the nerves, acting upon the muscles, can unlock an amount of activity wholly out of proportion to the work done by the nerves themselves.

As regards these questions of weightiest import to the science of physiology, Dr. Mayer, in 1845, was assuredly far in advance of all living men.

Mayer grasped the mechanical theory of heat with commanding power, illustrating it and applying it in the most diverse domains. He began, as we have seen, with physical principles; he determined the numerical relation between heat and work; he revealed the source of the energies of the vegetable world, and showed the relationship of the heat of our fires to solar heat. He followed the energies which were potential in the vegetable, up to their local exhaustion in the animal. But in 1845 a new thought was forced upon him by his calculations. He then, for the first time, drew attention to the astounding amount of heat generated by gravity where the force has sufficient distance to act through. He proved, as I have before stated, the heat of collision of a body falling from an infinite distance to the earth, to be sufficient to raise the temperature of a quantity of water, equal to the falling body in weight, 17,356° C. He also found, in 1845, that the gravitating force between the earth and sun was competent to generate an amount of heat equal to that obtainable from the combustion of

six thousand times the weight of the earth of solid coal. With the quickness of genius he saw that we had here a power sufficient to produce the enormous temperature of the sun, and also to account for the primal molten condition of our own planet. Mayer shows the utter inadequacy of chemical forces, as we know them, to produce or maintain the solar temperature. He shows that were the sun a lump of coal it would be utterly consumed in five thousand years. He shows the difficulties attending the assumption that the sun is a cooling body; for, supposing it to possess even the high specific heat of water, its temperature would fall 15,000° in five thousand years. He finally concludes that the light and heat of the sun are maintained by the constant impact of meteoric matter. I never ventured an opinion as to the truth of this theory; that is a question which may still have to be fought out. But I refer to it as an illustration of the force of genius with which Mayer followed the mechanical theory of heat through all its applications. Whether the meteoric theory be a matter of fact or not, with him abides the honor of proving to demonstration that the light and heat of suns and stars *may* be originated and maintained by the collisions of cold planetary matter.

Let us now go back ten years and see how this verdict was arrived at.

When Professor Tyndall was preparing his work on heat, he desired to acquaint himself with all that Mayer had done upon this subject. He accordingly wrote to two eminent Germans, authorities upon this question, for information. Both responded, and one of them, Professor Clausius, procured Mayer's publications to send to Tyndall. In his first letter he said he thought Professor Tyndall would not find anything very important in Mayer's writings. But before forwarding the memoirs he read them himself, and then wrote to Tyndall: "I must here retract the statement, in my last letter, that you would not find much matter of importance in Mayer's writings; I am astonished at the multitude of beautiful and correct thoughts which they contain." He then went on to point out various important subjects in the treatment of which Mayer had anticipated other eminent writers. Professor Tyndall perfectly agreed with Clausius, and resolved to do his share toward making so able and original a man better known in England. Accordingly, on June 6, 1862, he gave a most interesting lecture at the Royal Institution, full of new views and novel experiments, on the subject of "Force." At its close he remarked: "To whom, then, are we indebted for the striking generalizations of this evening's discourse? All that I have laid before you is the work of a man of whom you have scarcely ever heard. All that I have brought before you has been taken from the labors of a German physician, named Mayer. Without external stimulus, and pursuing his profession as town physician in Heilbronn, this man was the first to raise the conception of the interaction of natural forces to clearness in his own mind. And yet he is scarcely ever heard of in scientific lectures, and even to scientific men his merits are but partially known. Led by his own beautiful researches, and quite independent of Mayer, Mr. Joule published his

first paper on the 'Mechanical Value of Heat,' in 1843; but in 1842 Mayer had actually calculated the mechanical equivalent of heat from data which a man of rare originality alone could turn to account. From the velocity of sound in air, Mayer determined the mechanical equivalent of heat."

In October of the same year there appeared an article in "Good Words," under the title of "Energy," the joint production of Professors Thomson and Tait, which was called forth by Tyndall's June lecture on "Force." In this paper and in subsequent ones, defending it, the writers confess themselves startled at the recent attempt made "to place Mayer in a position which he never claimed," and they deny to him "the credit of being the first to establish in its generality the principle of the 'Conservation of Energy,'" and assert that "Mayer's paper (1842) has *no claims to novelty or correctness at all*, saving this, that by a lucky chance he got an approximation to a true result from *an utterly false analogy*"; and that "even on this point he had been anticipated by Séguin, who three years before the appearance of Mayer's paper had obtained and published the same numerical result from the same hypothesis." They claim that the honors of producing this theory are English throughout; that Newton, Rumford, and Davy established it, and that Dr. Joule, of Manchester, developed and matured it; and, impelled by a proper "scientific patriotism," they protest against this attempt of Tyndall to make over to a foreigner what belongs to his own countrymen, and is withheld by depreciation and suppression.

These positions were met and the whole case of Professors Thomson and Tait exploded in a series of communications addressed by Professor Tyndall to the "Philosophical Magazine." As to the statement that Mayer himself did not claim to be a founder of the "Dynamical Theory of Heat," Professor Tyndall quoted the following passage from a publication of Mayer's in 1851: "The new subject" (the mechanical theory of heat) "soon began to excite the attention of learned men, but, inasmuch as both at home and abroad the subject has been exclusively treated as a foreign discovery, I find myself compelled to make the claims to which priority entitles me; for, although the few investigations which I have given to the public, and which have almost disappeared in the flood of communications which every day sends forth, without leaving a trace behind, prove by the very form of their publication that I am not one who hankers after effect, it is not therefore to be assumed that I am willing to be deprived of intellectual property which documentary evidence proves to be mine."

As to the declaration that Mayer's views of 1842 had no novelty or correctness at all, save what he luckily blundered into, Professor Tyndall first quotes some counter-authorities. In Professor Helmholtz's celebrated discourse, delivered at Königsberg, in 1854, on the interaction of natural forces, this great physicist remarks, "The first man who

correctly perceived and rightly enunciated the general law of nature which we are here considering was a German physician, J. R. Mayer, of Heilbronn, in the year 1842." Again, M. Verdet, an eminent French authority, especially in the literature of science, in addressing the Chemical Society of Paris on the mechanical theory of heat in 1862, remarked: "I now come to the researches which, from 1842 to 1849, definitely founded the science. These researches are the exclusive work of three men * who, without concert and without knowing each other, arrived simultaneously in almost the same manner at the same ideas. The priority in the order of publication belongs, without any doubt, to the German physician, Jules Robert Mayer, whose name has occurred so often in these lectures; and it is interesting to know that it was by reflecting on certain observations in his medical practice that he perceived the necessity of an equivalence between work and heat. . . . He perceived in the act of respiration the origin of the motive power of animals; and the comparison of animals with thermic engines afterward suggested to him the important principle with which his name will be connected for ever. . . . We also find in the same memoir (1842) a first determination of the mechanical equivalent of heat deduced from the properties of gases, which is perfectly exact in principle."

How Dr. Mayer arrived at the mechanical equivalent of heat, has been briefly referred to by Tyndall in a previous quotation. It will not be possible here to go into the full detail of Mayer's method, but the reader who is curious about it may consult Tyndall's "Heat as a Mode of Motion" for a clear statement, and, for a still completer account, vol. xxviii. of the "Philosophical Magazine," Fourth Series, page 25. Before they had become familiar with Dr. Mayer's work, Professors Thomson and Tait had no word for him but that of disparagement; but, as his results were forced upon their attention, they were compelled to concede something to him, and so Tait admits, in 1863, that "Mayer's later papers are extremely remarkable and excessively interesting, and certainly deserve high credit." Yet his claim as the first to determine the mechanical equivalent of heat is still pointedly denied. Indeed, Professor Tyndall himself does not lay the highest stress upon this achievement of Dr. Mayer. He observes: "I must here say distinctly that I would not for an instant allow my estimate of Mayer to depend upon his determination of the mechanical equivalent of heat. It is the insight which he had obtained in advance of all other men regarding the relationship of the general energies of the universe, as illustrated in the whole of his writings, that gives him his claim to my esteem and admiration."

Now, undoubtedly the whole is greater than a part, and Mayer's fame has a far broader foundation than any one special result could afford. But we think that his determination of the mechanical equiv-

* Mayer, Colding, and Joule.

alent of heat, in the year 1842, with the resources he had, and the exactness which he attained, is one of the most marvelous exploits in the whole history of science, is incomparably his greatest achievement, and is sufficient alone to place him in advance of all the thinkers who have devoted themselves to this great research. And we apprehend that this would have long ago been conceded but for the rival claims of Dr. Joule to this discovery. It is admitted on all hands, and even by Mayer himself, that Joule's laboratory processes were necessary and invaluable in completing the work, and placing this truth upon its firm and experimental basis. With great patience and skill he worked out the law of the mechanical equivalence of heat, as a demonstration that all men can verify, and, by the award of the whole scientific world, that law is permanently connected with his name. But Joule's results were reached only in 1849, while Mayer had arrived at the same result by other methods in 1842. What was it that both men were driving at? It was the working out of a great relation, or the establishment of a universal truth of nature. Mayer reached it, by using the data that science had created for him. He got it first, he got it independently, and he got it exactly, or within a small fraction of the expression arrived at by Joule after six years of subsequent experiment. Mayer was the pioneer, the revealer, the creator of the theory, and Joule the verifier of his work. That verification was required and has made the name of Joule immortal; but who will compare it with that master stroke of genius by which from scanty materials the great truth was first independently seized and formulated? In 1849 Dr. Joule fixed the exact mechanical equivalent of heat after many laborious experiments, at 772 foot-pounds. Seven years previously Dr. Mayer pursued a method which gave the mechanical equivalent of heat as 771·4 foot-pounds.

It was alleged by Thomson and Tait, as we have seen, that Mayer's method had been adopted by the Frenchman Séguin, three years earlier, and that he anticipated the German in deducing the mechanical equivalent of heat. Séguin, in 1839, published a work on the steam-engine, in Paris; and that work contains a table on the relations of pressures, temperatures, and mechanical effects of steam, from which it was alleged that the mechanical equivalent of heat may be inferred. But the widest discrepancies existed among the interpretations of these tables by different authorities. Upon a careful investigation of the subject Professor Tyndall found that Séguin's and Mayer's numerical results did not refer to the same things at all, and that Séguin's tables did not attempt to give the mechanical equivalent of heat. Professor Tyndall says: "It is only necessary, however, to read the foregoing pages to see that Mayer and Séguin are speaking of two totally different things; that the degrees of the one are not the degrees of the other; that the 'temperatures correspondantes' of the latter, which refer to his compressed steam, are not thermal units at all, and

that there is no determination whatever of the mechanical equivalent of heat in the above table."

We have no space to go further into the particulars of this controversy, which was as discreditable to the assailants of Mayer as it was honorable to his disinterested defender. It is to be remembered that on all occasions, and in the most emphatic way, Professor Tyndall bore his testimony to the greatness of Dr. Joule's work, and deprecated every construction of his efforts which assumed that he was exalting the German at the expense of the Englishman. His demand was that Dr. Mayer be accorded a distinguished place among the founders of the modern doctrine of forces—such a place as he was incontestably entitled to by the scope, originality, and earliness of his work. But his opponents would allow the German doctor no merit whatever as a pioneer or discoverer, and no place in the circle of eminent men who created the new epoch of dynamical philosophy. The attack, however, upon Mayer signally failed of its intended purpose, and the parties who made it had the mortification of seeing that their ungenerous exertions were overruled to an end very different from that which they had designed. After the sifting and probing which followed the onslaught of the Scotchmen, the claims in behalf of Mayer were universally recognized as just; he was chosen by acclamation a member of the French Academy of Sciences, and the award of the Copley medal in 1871, the highest honor in the gift of the Royal Society of England, was the sharp rebuke of British Science to the unworthy efforts incited by a spurious patriotism to depreciate an illustrious foreign *savant*.

Dr. Mayer, as we have intimated, was a man of much suffering, which was undoubtedly aggravated by the neglect and injustice with which his labors were treated; and, when generous recognition of his services was made, the good effect on his disordered mind was palpable. It was while he was in the asylum, under treatment, that the Copley medal with Tyndall's accompanying letter was put into his hands. Dr. Mülburger, the attending physician, remarked, "I can still see him as he entered my room, beaming with gladness, to exhibit to me this rare distinction."

A monument is to be erected to Mayer at Heilbronn, and the scientific men of different countries are adding their contributions to those of his townsmen for the purpose of its erection.

CORRESPONDENCE.

LETTER FROM MR. KIDDLE.

To the Editor of the Popular Science Monthly.

THERE seems to be nothing so capable of throwing a "scientist" into a paroxysm of rage as the serious attempt to talk to him of *spirit*, *spirit-world*, "*spiritual body*," etc. In the words of Brewster, "*spirit* is the last thing he will give in to"; or, to put it in Huxley's mild way, "supposing the phenomena to be genuine, *they do not interest me.*" One might suppose that men whose habits of mind are the offspring of careful investigation and calm inquiry, would take any class of phenomena, and at least contemplate them with *scientific* patience, keeping their minds poised and ready to receive more light. But no; some favorite hypothesis seems to be in danger, and our modern philosopher, who either claims the paternity of it, or hangs to the skirts of him thus highly honored, has always a choice assortment of literary missiles to hurl at the trespasser. When a man feels that he can not meet another in fair argument, he usually greets him with such choice epithets as *fool*, *driveling idiot*, *lunatic*, etc., etc. How scientific! How worthy of a scientific journal is such mean and cheap scurrility!

Such is the temper in which you have chosen to assail me and my recently published book, "Spiritual Communications," in the June number of "The Monthly." Of course, I can not contend with you in throwing mud; your vocabulary of abuse is richer and stronger than any I could possibly command; and I acknowledge, therefore, that you have the advantage of me in this respect; but let me suggest to you that one who claims to be a scientist should resort to the weapons of logic, not the bludgeon of a ruffian. Nor was even this brutal treatment sufficient to satisfy your scientific instincts. You seemed to think your literary crucifixion would be incomplete unless you brought a murderer to share my fate; but remember that the greatest being that ever walked upon the surface of this planet was crucified between two thieves; and remember, too, who did it. "Woe unto the world because of offenses, but woe unto that man by whom the offense cometh!" Your article does, indeed, show the "survival of savagery."

The editor of this book may, indeed, claim some consideration for accredited ability to investigate phenomena brought to his notice, as well as yourself. What right have you, who know nothing of the facts—and will not listen to the evidence on which they rest—to abuse me for stating them, simply because they do not fit into your notions, your conceits, and your theories? The man who refuses to investigate, or listen to the results of investigation—who shuts his eyes against the sun of truth, and angrily protests there is no sun—he is the idiot; or, if he continues in that course, will soon become one. If you had read my book, you would have seen that, instead of setting aside all other spiritual revelations, that which is offered in the book strengthens and confirms the divine revelation of the Scriptures, and is presented in that relation to it; but it adds to it, and makes clear many things previously left in obscurity. Jesus said (John xvi. 12): "I have yet many things to say unto you, but ye can not bear them now." Science is constantly giving birth to new theories, as you yourself very well know. What, for example, is the science of chemistry now, compared to what it was when you first called at my school with your chart of its nomenclature? Why, then, should you quarrel with revelation if God chooses to expand it, and give us a little more spiritual light? Is your soul (excuse me, your *mind*) so bathed with heavenly radiance that you are afraid any addition to it will blind you?

Still, there is one part of your article on *savagery* that gives me real pleasure. You appear to be anxious for the integrity of "spiritual revelation." It does really appear as if you could look beyond the universe of matter to the far greater supersensuous world of God's creation. I congratulate you and the world upon this heavenly change. Who knows but the millennium may be at hand, when the lion will lie down with the lamb (outside of him), and the editor of "The Popular Science Monthly" will be able to read "Spiritual Communications" without losing his philosophic temper, and without becoming lost to all sense of scientific and literary decency?

I commend to you, in conclusion, the words of Mr. Parke Godwin, which you are, doubtless, able to recall: "Let us be assured that some truth has come a good while ago, that it is coming still, in many ways, and will come in broader and rosier flashes in the future, though not to him who, ostrich-like, buries his head in the sand, or muffles his eyes against any of its illuminations."

I have the honor to subscribe myself,

Very sincerely your friend,

HENRY KIDDLE.

NEW YORK, *June* 5, 1879.

LETTER FROM MR. BERGH.

To the Editors of the Popular Science Monthly.

On page 637 of your September edition, there is an article entitled "Death to the English Sparrow," which refers to a communication in the "American Naturalist," written by one Dr. Elliott Coues, recommending the extermination of that pretty little creation of the Almighty, and suggesting that boys be constituted their executioners.

Who this enemy to God, through one of his works, is, I know not—whether he be a Zulu or an American savage, I care not; but, since he has been permitted a space in two of our leading menstruals, out of deference to them, I have thought proper to notice the barbarism of the sentiment uttered by him.

This man dares to rebuke the Maker of all things, by calling the innocent little being "a wretched interloper," which has no place in the "natural economy of this country"; and he betrays his own place in the social and professional world by characterizing all who think otherwise as "silly old fogies," "*quasi*-ornithologists," and "*clacqueurs* of the *quasis*."

This person, who thus arraigns his Creator, and attributes human fallibility to the Infinite, belongs, it seems, to a profession which should purge itself of a fellow who has not the brains to comprehend the meaning of humanity and good policy, nor yet the fact that God has not created anything needlessly—not even Elliott Coues.

This inverted genius suggests the policy of founding a school wherein boys may be educated in the practice of murder, which of course includes all other social crimes.

It is true, he does not advise these boys to begin by killing their parents, or other human beings, but to commence with an innocent little bird; when, after an apprenticeship of a few years, he presumes they will be prepared to do the heavy business of throat-cutting, stabbing, and shooting.

This wonderful individual, when he conceived this grandest idea of his life, doubtless had in his mind "the physical fact"—as the Honorable Mr. Sloate would say—that there is a beginning to everything; that the mighty Mississippi at its source is but a tiny stream, and hence his pupils in time would graduate from his college with all the honors enjoyed by the most distinguished students of crime that have ended their days upon the scaffold.

But the refreshing tenderness of this medical practitioner—whom possibly some innocent invalid may have unwittingly called to his bedside—is best expressed by himself. He says: "Let the birds shift for themselves; take down the boxes and all special contrivances for sheltering and petting the sparrows; stop feeding them; stop supplying them with building material; abolish the legal penalties for killing them; let boys kill them; let them be trapped and used as pigeons, or glass balls in shooting-matches among sportsmen"!

It is said that the inventor of the guillotine was the first person to perish by it. O that this modern Æsculapius would only introduce his beautiful theory among us here in New York—for he is a resident of a much-to-be-envied Eastern State—so that the undersigned might profit by the opportunity of making him acquainted with the legal guillotine which he would certainly be compelled to ascend! HENRY BERGH.

REMARKABLE LIGHTNING-STROKE.

To the Editors of the Popular Science Monthly.

There recently occurred in our city a case of stroke by lightning which, no doubt, from its strange freaks, will be of interest to the readers of The Popular Science Monthly. It took place in a grocery-store, and two persons were the sufferers. The bolt, after tearing up the eaves of the house, entered it on the side, leaving a smutty stain between the cracks. It bulged out the side of the shop for several feet, put out the lamp, knocked down many articles from the shelves, took off the tops of several lamp-chimneys resting on them, completely tore off the paper wrappers of many small cakes of soap, and finally emerged at the corner of the room, tearing off several planks. In the passage of the current from one division of the shelves to the other, it either split the dividing boards or passed under them, partially fusing the nails and charring the adjacent wood. But what makes the stroke most remarkable is the way in which it affected the two men who were struck. One of them, Ware, was stunned for a few moments, had his pipe knocked from his mouth several feet away, and was left with a red, sore scar across his cheek and a paralysis of his arms, which latter remained for about two hours. Still more strangely did it deal with the other man, Bullard, who was resting upon the show-case opposite Ware. The current passed up his arm, under the armpit, down the right side of the body to the thigh, leaped across to the inner side of the left leg, and passed down the leg to the foot. It made a red bunch and sore mark upon the body, singed the hair from both legs, and left the sufferer unconscious for more than twenty-four hours. Both have fully recovered, with the exception of a little soreness. In both cases we noted the spiral direction of the current. The house was low, in a depressed situation, and protected with a rod. ROBERT F. JACKSON, JR.

MACON, GEORGIA, *May* 20, 1879.

PYTHAGORAS ON BEANS.

To the Editors of the Popular Science Monthly.

DEAR SIRS: Allow me to give expression to some thoughts suggested by reading the interesting article of Dr. Felix Oswald, in the April number of your publication. The author commits an error when he ascribes the forbidding, by Pythagoras, of using beans as an article of food to a deprecating view of it; it was just the opposite view that caused him to do so. I have before me an essay, "Pythagoras, the Sage of Samos," according to the latest researches, written by Eduard Baltzer (in German), who draws mainly on the "History of Philosophy," by Professor Roeth, of Heidelberg. Baltzer's work is the most successful of the different endeavors made to furnish, from the few fragments that have remained of his works, a biography of the greatest of ancient thinkers, the father of philosophy, as he has been truly called. Beans were forbidden for the common use of his followers, as they were considered a specially sacred article, and were only eaten at certain meals that formed a part of the Pythagorean *cultus*, the so-called Orphic mysteries.

The fundamental truth of preparing the body by a pure diet and pure physical habits for the growth of spiritual life, that formed the basis for all the doctrines of the ancient philosophers, and that has found the most distinct expression in the words of St. Paul, "Know ye not that ye are the temple of God, and that the spirit of God dwelleth in you?" etc., has become utterly darkened to the modern perception in its clumsy materialistic tendency—the very rudiments of instinct, the organic perception of the laws of nature underlying its structure, have been lost or utterly distorted by the wrong habits of a carnivorous race; and the modern man, with all his vaunted scientific acquirements, will yet have to go begging to antiquity to gather some crumbs of wisdom and truth. As the earth receives the effects of solar radiation, the source of all its organized physical life, only after it has been modified and polarized by its atmospheric medium—whereby the solar energy assumes, as it were, a geomorphous condition—just so all spiritual perception in the human mind becomes anthropomorphized, individually as well as generically, by the physical condition of the body; and the clear-eyed observer recognizes the cause of mental and moral anomalies in the condition of the physical postulates. Pessimism, as it seems to spread like a frightening nightmare through the race, is nothing but a spiritual perception, polarized to distortion by a bodily medium poisoned by tobacco and alcohol; and every one suffering from it can cure himself and become an optimist by adopting a pure Pythagorean diet, and thus armored draw truth from the wells of divine revelation. I feel free to say so, because, for the sake of experiment, I have changed myself backward and forward severally out of one state of mind into the other.

Returning to our beans, I find that there is no article of food equal to them for gaining the physical postulate for a higher spiritual soul-life. Wheat may be rightly called the best brain-food—next to wheat probably barley, but receiving a greater share of direct sunlight than the beans, which are surrounded by a thicker husk or hull than the grain; whereas the latter, receiving a greater share of indirect radiation through their larger leaves, the grain possesses a more positive vital polarity in its nutritive influence, and the bean a more negative one, whereby the former favors subjective, active, intellectual effort, and the latter predisposes to objective intellectual receptivity, the requirement for spiritual perception.

The New-Englanders, who may be called, I suppose, the salt of the American nation, in establishing baked beans as a national dish, have furnished a proof of the absolute wisdom manifested in the mysterious operations of the unconscious in human nature, as a modern pessimistic philosopher chooses to call the result of divine guidance in the inner life of man.

Respectfully, JULIUS ASHMAN.

NEW YORK, *April* 4, 1879.

EDITOR'S TABLE.

EXPLANATIONS THAT DO NOT EXPLAIN.

THERE is a certain class of minds whose efforts to explain things generally leave them more obscure than they were before. In undertaking to represent a question they complicate rather than simplify it, and instead of helping the learner to understand a subject they hinder him. This failure to make things lucid and comprehensible is due to various causes. Oftenest, it comes from a total neglect of the art of luminous writing, and it is unfortunate that many scientific men are not a little perverse about cultivating this art. They do not, as a matter of conscience,

make any effort to enter into the state of mind of the parties addressed, and their expositions, therefore, often fail from lack of adaptation. Sometimes a subject familiar to teachers of great capacity is still too abstruse to be grasped by common minds. Sometimes the expounder does not understand the subject himself; and not unfrequently hypotheses are invented to explain unexplainable things, and which serve only to increase existing difficulties. A marked illustration of this is afforded by a lecture delivered not long ago before the Royal Institution, by the eminent physicist and mathematician, Sir William Thomson, who announced as his topic of discourse the curious subject, "Maxwell's Sorting Demons."

The lecture was mainly devoted to an explication of the phenomena of the diffusion of liquids and the principles it involves. Professor Thomson had many tubes prepared, each containing two liquids of different colors, to represent the progress of diffusion, while some ingenious experiments were made by throwing the spectra of various solutions upon the screen with an electric light. The diffusibility of solids and gases was also referred to, and a just tribute paid to the memory of Graham, whose name stands most prominently associated with this branch of research.

Sir William Thomson's reasons, however, for bringing forward these phenomena of diffusion were that they stand very closely related to the present theories and speculations concerning the molecules of matter, and which aim to account for their motions. In diffusion, the molecules gradually intermingle, according to definite laws, which are variable in different cases. The molecules do not move capriciously or irregularly, as all chemical action and all crystallization prove. But why do they move this way or that, and why always go the same way in the same conditions? This "why" is the perplexing word of science, and when we get down among objects the very existence of which is hypothetical it carries us far beyond our depth. But Professor Maxwell thinks he gives us aid here by inventing a host of little demons—living creatures with wills and infallible intelligence—which sort the molecules and regulate their extraordinary motions. In a very brief abstract of his lecture which Sir William Thomson has published, he thus explains the attributes and offices of these remarkable agents:

> Clerk Maxwell's "demon" is a creature of imagination having certain perfectly well-defined powers of action, purely mechanical in their character, invented to help us to understand the "dissipation of energy" in nature. He is a being with no preternatural qualities, and differs from real living animals only in extreme smallness and agility. He can at pleasure stop, or strike, or push, or pull any single atom of matter, and so moderate its natural course of motion. Endowed ideally with arms and hands and fingers—two hands and ten fingers suffice—he can do as much for atoms as a piano-forte player can do for the keys of the piano—just a little more, he can push or pull each atom *in any direction*.
>
> He can not create or annul energy; but, just as a living animal does, he can store up limited quantities of energy, and reproduce them at will. By operating selectively on individual atoms he can reverse the natural dissipation of energy, can cause one half of a closed jar of air, or of a bar of iron, to become glowingly hot and the other ice cold; can direct the energy of the moving molecules of a basin of water to throw the water up to a height and leave it there proportionately cooled (1° Fahr. for seven hundred and seventy-two feet of ascent); can "sort" the molecules in a solution of salt or in a mixture of two gases, so as to reverse the natural process of diffusion, and produce concentration of the solution in one portion of the water, leaving pure water in the remainder of the space occupied; or, in the other case, separate the gases into different parts of the containing vessel.
>
> The classification, according to which the ideal demon is to sort them, may be according to the essential character of the atom: for instance, all atoms of hydrogen to be let go to the left, or stopped from crossing to

the right, across an ideal boundary; or it may be according to the velocity each atom chances to have when it approaches the boundary: if greater than a certain stated amount, it is to go the right; if less, to the left. This latter rule of assortment, carried into execution by the demon, disequalizes temperature, and undoes the natural diffusion of heat; the former undoes the natural diffusion of matter.

This looks to us like a somewhat ridiculous way of evading the real difficulties in the explanation of molecular motions and their effects. All nature is supposed to be filled with infinite swarms of absurd little microscopic imps, which are so omniscient that they direct the invisible and insensible movements by which the whole order of nature is determined and maintained. When men like Maxwell, of Cambridge, and Thomson, of Glasgow, lend their sanction to such a crude hypothetical fancy as that of little devils knocking and kicking the atoms this way and that, in order to explain the observed changes of natural phenomena, we may well ask, What next? This is a palpable case of contriving an artifice to explain a subject which yet leaves the subject more obscure than ever. There were difficulties enough with the molecules considered alone, but when complicated with another hypothetical order of beings the difficulties are redoubled, for we have now to explain the explanation. There is a great proneness to invent explanations which only remove the trouble one step further away. Sir William Thomson's hypothesis of the origin of terrestrial life by means of germs, brought to our planet from some unknown source by meteorites, is another example of explanations by assumptions, in which nothing is explained. There is a class of scientific men who feel it incumbent upon them to answer all questions. They do not seem to appreciate the fact that there are limits to our knowing, which had better be honestly acknowledged, instead of offering conjectures which are mere travesties of legitimate theory, and absurdities in science.

MR. BERGH AND THE SPARROWS.

We print an indignant letter from Mr. Bergh the philanthropist, denouncing one of our eminent ornithologists for saying that the English sparrows among us are interlopers, and, instead of being protected, should be left to shift for themselves, and be exposed to the raids of the street boys. We have a very high respect for Mr. Bergh and his mission, and have never been disposed to criticise his peculiarities or find fault with the way in which he has chosen to perform his duty. It is enough that such a man was greatly needed in the community, and it is not well to raise questions of taste, or to carp at mistakes committed in the performance of a disagreeable but most beneficent public service. We cordially approve of his practical work in protecting animals against the infliction of cruelty, whether from wantonness, carelessness, or insensate stupidity. But because Mr. Bergh's labors are important they ought to be maintained on proper grounds; though, judging from his letter, we should rather trust his instincts than his logic.

As regards the sparrows, Mr. Bergh seems not to recognize that they are at present under indictment, and, while we have no disposition to prejudge their case, it certainly is not to be settled on purely sentimental grounds. The question of their treatment depends upon whether or not they have become pests and nuisances. If it is true, as maintained by reputable naturalists and those who have observed their habits and history, that these birds are extremely prolific, hatching out several broods in the same season, and that, besides this, they have been so coddled and cared for as greatly to

increase the usual rate of their multiplication; if it is true that they are quarrelsome and pugnacious little creatures, and by their bad dispositions and excessive numbers are driving out other birds, and consuming the means of subsistence, which all should share, and, moreover, if they are specially destructive to buds, fruits, and grains, as is also alleged, so that on the whole they may do a great deal more mischief than good — then it is just as proper to destroy them as to destroy any other pests. If such is their character, protection should be withdrawn from them, and they should be exterminated in all suitable ways. Mr. Bergh ought to have addressed himself to these considerations, and shown if he can that the charges against the sparrows are false, and that they are entitled to all the favors they get.

But he puts the case on different grounds. He objects to the killing of his pets for teleological reasons—that is, because it thwarts the purposes of Divine Beneficence, and, by the prominence he gives to this notion in his letter, we must assume that he regards it as imperative. He looks upon Dr. Coues as a man who would exterminate one of the "pretty little creatures of the Almighty," and that he is therefore an "enemy of God"; and Mr. Bergh expresses a somewhat sanguinary wish that he could get hold of him, and subject him to the guillotine of New York law.

Now, there is something wrong here. Whenever one party wants to give another party the law in the name of God, the matter requires looking into. Mr. Bergh assumes to know the Divine intentions: does he probably understand much more about them than his neighbors? He seems somewhat reckless in his mental movements, but is he not aware that the water hereabouts is very deep? He plays off theology upon Dr. Coues, but we suspect that the naturalist might give the philanthropist large odds, and still beat him at the game.

For when Mr. Bergh says to Dr. Coues, "You would let loose the street boys upon the sparrows, and are therefore an enemy of God," Dr. Coues may reply: "How do you know that the propensities of boys are not among the divinely appointed means of dealing with sparrows? And if it is a question of Divine purposes, who created the sparrow-hawk—the most destructive little savage ever set free in the sky? If you wish some pointed information regarding the intentions of the Almighty in respect to the treatment of sparrows, consult the excellent volume on birds by the Rev. J. G. Wood, page 85."

Should Mr. Bergh see fit to comply with the suggestion, he will there find that sparrow-hawks for some purpose have been provided on a very large scale, being plentifully found in all quarters of the world. That it may do its work of destruction effectually, the sparrow-hawk was made one of the most vicious, sanguinary, and cruel of all birds of prey. Usually very wild, shy, and wary, it is difficult of approach, except when "hovering about a flock of sparrows," and then "the ardor of its destructive propensities is so great that all its faculties seem to be absorbed in the gratification of the ruling passion, so that it is evidently unmindful of anything but its flying prey. A sparrow-hawk has even been known to dash furiously at a man, who endeavored to rescue a small bird which it attacked."

Hawks, as is generally known, are capable of being domesticated and trained to hunt as in the art of falconry; but the sparrow-hawk is so fierce and untamable that it is the worst of all its tribe for this purpose. It is indeed courageous, and will dash at any quarry that may be pointed out to it, but it is crabbed, intractable, and so treacherous that it can not be trusted. Besides, it "is so quarrelsome that if

several of these birds should be fastened to the same perch or placed in the same cage they will certainly fight each other, and in all probability the conqueror will eat his vanquished foe! Such an event has actually occurred, the victrix —for it was a female—killing and devouring her intended spouse." A naturalist, writing in the "Field" newspaper, gives a very interesting account of the proceedings of "this handsome little hawk," showing it to be a most vicious wretch, and thus sums up its character: "The sparrow-hawk is, in my opinion, the wildest, in some sense the most intractable, the most ungrateful, the most provoking and temper-trying of all birds or beasts that ever were taken under the care of man from the beginning of the world."

"Now," Dr. Coues might say to Mr. Bergh, "if it be true, as Professor Agassiz always maintained, that animals are but embodiments of Divine ideas, we must consider this hawk, with its destructive weapons and murderous instincts, as representing the Divine conception of the sort of discipline to which sparrows should be subjected. It is divinely designed that their numbers should be kept down, so that other birds may have a chance. You thwart the Divine intention by artificially fostering them, and bringing about an unnatural state of things that is injurious. I would leave them to the Creator's universal and fundamental law of natural selection, which is a safer guide than blind, impulsive philanthropy, and I merely included street boys, with hawks, parasites, and a thousand other destructive agencies as the means of preserving the great balance among the orders of life."

The difficulty with Mr. Bergh is, that he puts behind his philanthropy, and as an impelling motive to it, an erroneous view of nature. The doctrine of Divine designs is a dangerous one to handle, because it cuts both ways, and proves too much. If the beneficent indications in nature are to be accounted for on the hypothesis of "intentions," so must the maleficent indications, and how are we to escape from the conclusion that cruelty also is designed? If we should say that the world was constructed and is administered on the principle of the "prevention of cruelty to animals," would it be quite true? Are not the means and appliances of destructive cruelty universal, and, if "intended" at all, were they not intended for their cruel uses? It would require an extensive museum to show us all the exquisite contrivances with which living creatures have been furnished to torment and kill each other. They were not made each with a gland to secrete chloroform that might be used in producing painless death. But, in place of any such kindly contrivance, there are claws, talons, beaks, tusks, fangs, hooks, saws, blades, stings, and malignant poisons in infinite variety of modification and adaptation for crushing, rending, tearing, lacerating, and torturing living and sensitive creatures; and these grim implements are furnished to all the grades of animate beings on the earth, in the sea, and in the air, from microscopic infusoria to colossal beasts that range the forests. Nor is this all: the creatures that are armed with these weapons of destruction are animated by the deadliest instincts to use them; in fact, they are driven to it by the very law of self-preservation. "Kill, that you may live," is the mandate of universal necessity.

But the roots of all this pitiless carnage strike still deeper into the method of nature. Life is wasted through these sanguinary devices with an infinite prodigality. Sensitive organisms to be sacrificed by suffering seem to be the cheapest things in the universe. The amount of inanimate matter is limited; but creatures formed out of it, and capable of pain, are boundlessly unlimited. Space restricts the material, but living organisms are multiplied for

ever in time. Destruction but makes room for more destruction; and not only is the onflowing river of life full to its banks, but ten thousand-fold more creatures are born than can be preserved. Each species reproduces at a rate that is out of all relation to the possible means of subsistence. If Mr. Bergh's sparrows could multiply at their normal rate, unchecked by the agencies of decimation, they would take possession of the world, and humanity and philanthropy would end together. And so it has ever been through the countless ages of the earth's history; so that its very rocks, for miles in depth, are filled with the fossil remains of innumerable tribes of creatures, which warred with each other through geological periods, and have now utterly perished. And it is to-day as it has been through the immeasurable past—millions of species scattered over the earth's surface, from pole to pole, are engaged in a struggle for existence, that is carried on everywhere with unrelenting severity.

From the point of view of sentiment alone, this is not a pleasant picture. Considered by itself, a hawk with a sparrow in its talons is not suggestive of beneficent intentions. If all this remorseless destruction has been beneficently designed, we must widen our notions of beneficent design. Science does this, by showing that out of the universal agony Nature is slowly, very slowly, working up to a better condition of things. In the sanguinary struggle the fittest survive, the ill-adapted and less perfect are slain, and there comes improvement. The value of this progress is to be estimated by its terrible cost. Through the destruction of tribes with what seems an almost infinite wantonness have finally come creatures with higher capacities of enjoyment, as well as correlative suffering, and an order of beings that have acquired great power over the conditions of pleasure and pain. In man, the last term of advancement in the animate series, ameliorations and modifications of his primal savage propensities have gone on, until there has grown up a set of feelings that are kindly, merciful, sympathetic, and benevolent; and they have at length become so strengthened and organized in our nature that they are characterized as "the humane sentiments," or the "spirit of humanity." These are the final product of man's moral evolution, and, although the reminiscences and survivals of savagery in the shape of military systems still linger, yet the kindly, merciful, and generous emotions are steadily gathering force in the hearts of men, and are becoming more and more the predominant law of the social state. Terrestrial life has had a tragic history, but, when under the stern discipline of a mortal competitive strife the primitive cannibals have been so utterly transformed that many of their descendants have come to find their highest pleasure in the gratification of the sympathetic feelings, and even to regard the brute creation with a tender solicitude, as evinced by the organization of societies for the prevention of cruelty to animals, who shall say that the grandeur of the end does not justify all the terrible means by which it has been attained?

LITERARY NOTICES.

THE EVOLUTION OF MAN: A POPULAR EXPOSITION OF THE PRINCIPAL POINTS OF HUMAN ONTOGENY AND PHYLOGENY. From the German of ERNST HAECKEL, Professor in the University of Jena, author of the "History of Creation," etc. In two volumes, with 330 Illustrations. New York: D. Appleton & Co. Pp. 970. Price, $5.

THIS work is now the great text-book of a great subject. Darwin wrote on "The Descent of Man," and Haeckel, with greater learning, writes later upon the same subject. The interest in these volumes will mainly depend, of course, upon the reader's interest in the questions it considers. Those who wish

to know how the problem of the origin of man now stands in the light of science, whether they believe in the doctrine of evolution or not, will turn to this exposition of it by one of the first of living biologists, and thus satisfy their curiosity and post up in a discussion which is beginning to engross a large share of the attention of thoughtful men all over the world. Those who accept the doctrine of evolution and wish to become familiar with its higher applications to organic life, and whose concern with the subject is strictly scientific, will also turn to this work to get the latest and fullest knowledge that has been reached concerning the development of man, and with no other solicitude than to obtain the truth. Yet the book in its subject matter is so greatly in advance of the intelligence and liberality of the age that multitudes will care nothing about it. The mass of people have but precious little curiosity as to where they came from, or how they got here. They generally have some belief about it, which they acquired early, and hold satisfactory, and do not care to have disturbed. To all such, scientific inquiries into these questions are mere impertinence. Then there are others who have a strong antipathy to all these investigations into the germ history of man. As Professor Haeckel remarks: "If we say that each human individual develops from an egg, the only answer even of most so-called educated men will be an incredulous smile; if we show them the series of embryonic forms, developed from this human egg, their doubt will, as a rule, change into disgust." It will obviously be a long time before such prejudices are overcome and there arises a general desire to know the facts concerning the genealogy of man, and his real place in nature. People must apprentice themselves a long time to the study of evolution among the lower forms of life, before they are willing to include themselves in the inquiry. Meantime there are many who are alive to the magnitude and import of the investigation, and these will cordially welcome a treatise from Haeckel on "The Evolution of Man."

Professor Haeckel some years ago published a comprehensive work on "The Natural History of Creation." It was an exposition of evolutionary doctrine through the widest circle of biological phenomena, and was of a much more general character than the present treatise. The development of man is, of course, confined to a consideration of the genesis of the human race. This subject, however, can not be treated alone; and, although it is in a certain sense a sequel to the first work, it is nevertheless much occupied with questions belonging to the general domain of life. The derivation of man is a question of kinship with the whole series of ancestral forms. Haeckel is so much of a pioneer in a great field, hitherto scantily cultivated, that he assumes the right of forming his own terminology, and hence we meet with various unfamiliar words in his pages, although he always makes them clear, and makes them contribute to the clearness of his discussion. The present treatise, devoted to anthropogeny, is divided into two parts: the first, ontogeny, or the history of individual human organisms, concerns itself chiefly with germ history or embryology; and the second, on phylogeny, is a history of the evolution of the various animal forms, from which man has descended in the course of countless ages. Phylogeny is thus a history of evolution, and embraces the sub-sciences of paleontology and genealogy. These terms mark out the divisions and scope of the work, and show that it is occupied with the radical problems of the subject.

Though strictly scientific, this treatise of Haeckel's is in a remarkable degree popular in style and form. It is written with great clearness, and with a view of rendering the subject attractive, and its profusion of elegant wood cuts and colored plates greatly enhances its interest. The time has not come when all biologists will agree with Haeckel as to the genealogical chain that he has made out from man to the moner, and much of his work may be long held as speculative. But Haeckel strenuously maintains that dissent from his array of proofs must be due to their not being sufficiently weighed, or to the bias of rival hypotheses. He writes with the ardor of a man intensely convinced, and with the lucidity and grasp of one thoroughly familiar with the wide elements of his subject. The book may be commended without hesitation to all who wish to acquaint themselves

with what is doing for the advancement of biological evolution.

MOORE'S RURAL LIFE. An Illustrated Journal for Suburban, Village, and Country Homes. Conducted by D. D. T. MOORE. 24 pages; $1.50 per year. 34 Park Row, New York.

THE "Rural New-Yorker," an excellent paper, was long managed by Mr. D. D. T. Moore, who now brings his tact, resources, and ripened experience to the establishment of a new enterprise which is admirably initiated, and we have no doubt will meet with the liberal patronage it deserves. Mr. Moore has taken pains to make the first number (for June) of his journal represent the ideal of what the succeeding numbers shall be; and does not send out a hastily prepared sample full of apologies for defects and promises of what he will do when the project gets fairly under way. Moore's "Rural Life" is splendidly illustrated and beautifully printed, and we can give the reader no better idea of the wide and judicious variety of its contents than by enumerating the departments under which its numerous articles are distributed: "Rural and Suburban Homes," "Landscape Gardening," "The Floriculturist," "The Fruit-culturist," "The Arboriculturist," "Entomological," "The Vegetable Garden," "Poultry and Pet Stock," "Editorial Department," "Sketches of Life," "Literary Miscellany," "Natural Science," "Our Book-Table," "Fancy Work and Fashion," "Domestic and Hygienic," "Out-Door Amusements," "Life in the Country," and "Young Folks' Life."

REPORT ON LIFE-SAVING APPARATUS. Made by Lieutenant D. A. LYLE, Ordnance Department, United States Army. Washington: Government Printing-Office, 1878. Pp. 156, with 54 Plates.

THE life-saving apparatus, with which this report is concerned, are mainly guns and projectiles designed for the purpose of carrying a line to an imperiled vessel, or from such vessel to the land. Numerous experiments, made under the direction of Lieutenant Lyle, with different kinds of guns and projectiles, and here recorded in full detail, will doubtless tend to increase the efficiency of our life-saving stations.

A TREATISE ON CHEMISTRY. By H. E. ROSCOE, F. R. S., and C. SCHORLEMMER, F. R. S. Volume II. Metals. Part I. New York: D. Appleton & Co. Pp. 504. Price, $3.

WE spoke of the character of this elaborate and sterling treatise on chemistry, in noticing its first volume, some months ago, and can add nothing now to what we said then in commendation of it, except that the present volume sustains all the promise of the first. We are, however, happy in being able to give the discriminating testimony of one of our highest chemical authorities as to the character of the present volume. Professor Josiah P. Cooke, of Cambridge, having been presented with a copy by the publishers, thus speaks of it: "I received the book several weeks ago, but have waited before acknowledging the gift until I could express an intelligent opinion upon its merits. I find that it fully sustains the reputation of its authors, and has the same merits which were so conspicuous in the first volume. The descriptions of manufacturing processes are remarkably full and clear, and the wood-cuts by which they are illustrated admirable. The book will be a great aid in teaching on that account, and I shall be able to refer students to it with satisfaction. Another conspicuous feature of the book is, that it makes prominent many points in the history of chemistry which it is not only a great convenience to have collected, but also very important should not be forgotten by the rising generation of chemists. Lastly, the mechanical execution of the book leaves nothing to be desired and makes it a pleasure to refer to it. I shall await the publication of the second half of the volume with great interest."

THE ART OF QUESTIONING. By JOSHUA G. FITCH, M. A. Syracuse: Davis, Bardeen & Co. Pp. 80. Price, 15 cents.

THIS is the abridged form of a little work published some years ago, by Professor Fitch, when Master of the Borough Road Training School, London, from which he passed to the position of one of her Majesty's Inspectors of Schools. He is an able man, and was a skillful practical teacher. The "Art of Questioning" will be found to contain many hints and suggestions that will be helpful in schoolroom management.

FIRST STEPS IN POLITICAL ECONOMY. By JOSEPH ALDEN, D. D., LL. D. New York: Baker, Pratt & Co. Syracuse, N. Y.: Davis, Bardeen & Co. Pp. 153. Price, 25 cents.

IN this little volume Dr. Alden has furnished us with an invaluable common-school manual, which can not too soon or too generally be put into the hands of American youth. It is the best introduction to political economy for beginners in primary schools that we have seen, and its universal adoption as a part of the course of elementary study could not fail to result in ultimate widespread benefit. The aim of the author has been "to present simple elementary truths connected with the business activities of life," and this he has done with excellent judgment as respects the subjects chosen and with remarkable clearness and simplicity of statement. There has been a good deal of caviling recently as to whether there is or is not such a science as political economy. No doubt, the excess of modern controversial literature over unsettled questions in political economy has favored this skeptical state of mind; but any one who will look over a little summary of elementary principles like this of Dr. Alden's must be satisfied that there is a broad basis of established truth on which a strict economical science can securely rest.

NOTES BY A NATURALIST ON THE CHALLENGER: being an Account of Various Observations made during the Voyage of H. M. S. Challenger round the World, in the Years 1872–'76. By H. N. MOSELEY, F. R. S. With a Map, Two Colored Plates, and numerous Woodcuts. New York: Macmillan & Co. Pp. 620. Price, $7.50.

THE opportunity afforded by a four years' sea-saunter in a ship, and with a party dedicated to scientific exploration, was well improved by Mr. Moseley, as is evinced by this goodly volume. Not by any means that the book embodies the scientific results of his extended observations, which when finally worked up will appear in other shapes, but it presents a great deal of interesting scientific and semi-scientific matter in connection with a readable and varied narrative of the experiences of the expedition. It is an especially well-executed book of travels, by an intelligent and thoroughly-trained observer, laboring in circumstances especially favorable for collecting interesting information. The main portion of it was prepared for family reading, written on board the Challenger, and sent home in the form of a journal from the various ports touched at. The materials have been carefully revised, but they take the character of a narrative describing the scenes, the aspects of nature, the curiosities and novelties of animal and vegetable life, and the characters, habits, and social conditions of the different kinds of people encountered along the route. The volume is written in a pleasant, unambitious style, but often with humorous touches and lively descriptions, which increase the attractiveness of its contents. The following passages express some of the impressions of the author, after his return, and are given at the close of his book:

After a voyage all over the world, there is nothing which is so much impressed upon the mind as the smallness of the earth's surface. We are apt to regard certain animals as fixed and stationary, and to contrast strongly with their condition that of forms possessing powers of active locomotion. In reality we are as securely fixed by the force of gravity as is the sea anemone by its base; we can only revolve as it were at the end of our stalk, which we can lengthen or shorten only for a few miles' distance. We live in the depths of the atmosphere as deep-sea animals live in the depths of the sea. We can, like these, crawl up into the shallows, or we can occasionally mount at peril in a balloon; but the utmost extent of our vertical range is a distance no greater than that which we can walk in a couple of hours horizontally on the earth's surface.

The Challenger traveled, on the voyage from Portsmouth and back to the same port, 68,690 miles, and this distance, taking into consideration the time consumed from port to port, was traversed at the average pace of only four miles an hour, or fast walking pace. In an express train on land the entire distance could be conceived of as being accomplished in eight weeks, and, at the rate at which a swallow can fly, in about half that time.

The earth, considered as a comparatively insignificant component particle of the universe, may be justly compared to a small isolated island on its own surface. As, in the course of ages, such an island develops its own peculiar insular fauna and flora, so probably on the surface of the earth alone has the peculiarly complex development of the element nitrogen occurred which has resulted in the various forms of animal and vegetable life.

On the theory of evolution, it is impossible that plants or animals of any advanced complex-

ity, at all resembling those existing on the earth should exist on other planets or in other solar systems. It is conceivable that very low forms of vegetable life may exist on other planets and may have been by some means transported to the earth; the idea is conceivable, though highly improbable. But it is quite impossible that that infinitely complex series of circumstances which on the earth has conspired to produce from the lowest living forms a crustacean, for example, should have occurred elsewhere; still less is it possible that a bird or a mammal should exist elsewhere; still more impossible, again, that there should be elsewhere a monkey or a man.

With regard to any future scientific expeditions, it would, however, be well to bear in mind that the deep sea, its physical features and its fauna, will remain for an indefinite period in the condition in which they now exist and as they have existed for ages past, with little or no change, to be investigated at leisure at any future time. On the surface of the earth, however, animals and plants and races of men are perishing rapidly day by day, and will soon be, like the dodo, things of the past. The history of these things once gone can never be recovered, but must remain for ever a gap in the knowledge of mankind.

The loss will be most deeply felt in the province of anthropology, a science which is of higher importance to us than any other, as treating of the developmental history of our own species. The languages of Polynesia are being rapidly destroyed or mutilated, and the opportunity of obtaining accurate information concerning these and the native habits of culture will soon have passed away.

PROBLEMS OF LIFE AND MIND. By GEORGE HENRY LEWES. THIRD SERIES, PROBLEM THE FIRST. THE STUDY OF PSYCHOLOGY, ITS OBJECT, SCOPE, AND METHOD. Boston: Houghton, Osgood & Co. Pp. 189. Price, $2.

THIS work was left unfinished by the author at his death last year, and it has been edited and prepared for the press, as is understood, by Mrs. Lewes, who prefixes to the volume this brief note: "The following problem is published separately, in obedience to an implied wish of the author, and has been printed from his manuscript with no other alterations than such as it is felt certain that he would have sanctioned. Another volume will appear in the autumn."

Like all of Mr. Lewes's philosophical writings, this book is worthy the attention of those interested in the subjects he discusses, for he had an acute and fertile mind, wayward if not independent, and by no means wanting in originality. But he was too versatile for preëminence. A man can not be great in all things, nor really great in anything if he dabbles in everything. Mr. Lewes was novelist, dramatist, linguist, critic, editor, physiologist, historian of philosophy, and psychologist. Much of his work was poor, much middling, and some of it excellent, but he left no impression upon any one subject such as he might have made by concentrating his powers upon it with an exclusive devotion. He was a brilliant talker, and an admirable story-teller; was sought by society, and was fond of of it, all his striking and varied acquisitions coming readily into play in cultivated social circles. In the latter portions of his life he was more secluded, and gave himself more closely to a restricted line of serious study which resulted in the publication of his maturest work, "The Problems of Life and Mind," of which the present volume is the last issued. He will probably be longest known by his "History of Philosophy," but in the present transition state of biological and psychological theory these latter works will be found well worth consulting. The volume now issued is expository and controversial with regard to various important psychological questions, but propounds little that is new, the author being content to reargue more fully various positions that he has heretofore assumed. It has undoubtedly been improved in style by passing through the editorial hands of Mrs. Lewes.

CHEMICAL EXAMINATIONS OF SEWER-AIR. By Professor WILLIAM RIPLEY NICHOLS. Boston: Rockwell & Churchill print. 1879. Pp. 20.

DR. NICHOLS is careful to employ the term "sewer-air" instead of "sewer-gas," inasmuch as the latter phrase gives rise to the erroneous idea that in sewers there exists a distinct gaseous substance possessed of marked distinguishing characteristics; whereas the fact is, that the gas or air of sewers is a continually varying mixture of the gases which make up the atmosphere, blended with a relatively small proportion of certain other gases formed by the decomposition of the sewage, together with aqueous vapor and vapor of organic compounds. The noxious substances in sewer-air would appear to be either minute solid particles or else particles of vapor, and not gaseous.

PRACTICAL PHYSICS, MOLECULAR PHYSICS, AND SOUND. By FREDERICK GUTHRIE, Ph. D., of the Royal School of Mines, London. New York: Henry Holt & Co. Pp. 156. Price, 60 cents.

THIS is one of a series of hand-books now being published, and which are said to be designed for students and general readers. The grade of these works is intermediate between the so-called Primers and the larger works, professing to give detailed views of the respective subjects. The author in his preface says that his object is, to get beyond mere word-knowledge of the subject. We do not think he has succeeded in this with his book. As a practical and experimental teacher, he may take students through a course in his laboratory and use the book, but the guidance will be given by the instructor and not by the volume. It does not seem to us to be at all a satisfactory guide to that "practical work" which Professor Guthrie says it has been the object of physicists of late years to bring into their teaching. Such books should be skillfully constructed to promote the self-help of pupils, and we see no trace of this quality in the present hand-book. There is a good deal of scientific information in the volume, of course, but much of it runs into mathematical expression which makes it unsuitable for general readers and ordinary students. The illustrations are indifferent, to say the least; the elementary experiments to illustrate sound and waves are postponed to the close of the volume, and no figures are given to illustrate them. A list of the materials required to make such experiments closes the volume. In short, the book seems to have been produced by an inexperienced educator, though its author has evidently a good knowledge of its subject.

HEARING, AND HOW TO KEEP IT. By CHARLES H. BURNETT, M. D. Philadelphia: Lindsay & Blakiston. Pp. 152. Price, 50 cents.

THE multiplication of health-books is a good sign. If they were not wanted they would not be published, and if they are bought it is to be inferred that they are read. Attention is therefore being drawn to the subject, and, when it is sufficiently thought about and permanent interest in it awakened, great practical good will be certain to result. Dr. Burnett's volume is the first of a series of "American Health Primers," and if the subsequent works are as good as this the series will be valuable. The first part of his little volume is devoted to the structure and physiology of the ear, and it is illustrated by excellent diagrams. The second part is devoted to diseases of the ear, with hints regarding their management, and to the care of the ear in health. It is a judiciously written and very useful little monograph.

THE ART OF SINGING. By Professor FERDINAND SIEBER. Translated from the German, with the Addition of an Original Chapter on the Hygiene of the Voice, by Dr. F. Seeger. New York: William A. Pond & Co. Pp. 175.

PROFESSOR FERDINAND SIEBER'S "Catechism of the Art of Singing" is a standard work in Germany, where it has passed through many editions, and Dr. Seeger has done an excellent service to the community in translating it. His familiarity with the structure of the vocal organs and his wide experience in treating them when out of order have drawn his attention to the art of singing as related to health, and induced him not only to render into English Sieber's valuable work, but to prefix to it an interesting and instructive essay on "The Hygiene of the Voice." Those interested in the art of singing, either theoretically or practically, will find this volume well worth consultation.

A POPULAR TREATISE ON THE CURRENCY QUESTION. Written from a Southern Point of View. By R. W. HUGHES, United States Judge of the Eastern District of Virginia. New York: Putnams, 1879. Pp. 222.

THE author of this essay argues against "inflation," and warmly approves the national banking system. He condemns the demonetization of silver, and holds that "the public debts of the world can not be paid, nor even their interest met, in gold at an appreciated value. . . . The legal-tender quality," he predicts, "will ere long be restored to silver throughout Europe." But, if that quality is not restored, then "there will be left the alternatives of diluting the currency there with paper money, or the civil convulsions which the Socialists and Communists stand ready to inaugurate."

REPORT OF THE PUBLIC AND HIGH, ALSO OF THE NORMAL AND MODEL SCHOOLS OF ONTARIO, FOR THE YEAR 1877. Toronto: Hunter, Rose & Co. print, 1879. Pp. 251.

THERE is much in this report to which we should like to call attention, but we can find space only for a few passages from the section entitled "Physical Science." "We are pleased," write the Inspectors of High Schools, "to be able to report that the teaching of physical science is making real progress in the high schools. After some experience of the practically inoperative and too expensive programme which was universally in force some years ago, it was decided by the Council of Public Instruction to limit the amount of work prescribed in this department, with the view of having a little done well. It was accordingly determined that only one of the physical sciences should have a place in the programme of lower school-work. On account of its intimate connection with the other physical sciences, and its great practical value, chemistry was selected, and the results have justified the policy adopted. . . . In a considerable number of schools enthusiasm for chemistry is manifested by both the teacher and his pupils. . . . The number of teachers capable of teaching chemistry has largely increased, and the number of pupils who are afforded the opportunity of beginning the study of that branch of knowledge in a proper manner is greater than ever before."

WORD AND WORK: OR, SCIENTIFIC AND MOSAIC GEOGONY COMPARED. By P. G. ROBERT, a Presbyter of the Diocese of Missouri. St. Louis: W. B. Chittenden. 1879. Pp. 29.

THE writer of this essay would be a mediator between Science and the Bible, but fails to exhibit his credentials as referee from either side. The world of science surely is not prepared to accept his exposition of the facts of geology; and his exegesis of Scripture passages is altogether too light and airy to meet the approval of Biblical scholars. As for the class of devout believers in the letter of the sacred word, they must be shocked at the author's temerity in explaining away the manifest meaning of the inspired record.

THE WISCONSIN TORNADOES OF MAY 23, 1878. By W. W. DANIELLS, Professor in the University of Wisconsin. Pp. 41, with Plates.

THE meteoric phenomenon described in this pamphlet was the simultaneous occurrence of three separate tornadoes in a comparatively narrow belt of country in southern Wisconsin. That there *were* three separate tornadoes appears evident from the observations made on the spot by Professor Daniells. The perpendicular velocity of the wind in such tornadoes can be appreciated from certain calculations made by the author of this pamphlet. At a point in the track of one of these three tornadoes a horse, weighing about 1,100 pounds, was carried over twenty rods; in another place a horse, of about the same weight, was carried eighty rods. Now, a horse of this size would not expose a lifting surface to the wind of over fourteen square feet. To lift such an animal, then, would require an upward pressure of the air of $\frac{1100}{14} = 78{\cdot}5$ pounds per square foot. This pressure is produced by wind moving with a velocity of 124·6 miles per hour.

AN ETYMOLOGICAL DICTIONARY OF THE ENGLISH LANGUAGE, ARRANGED ON AN HISTORICAL BASIS. By Rev. W. W. SKEAT, A. M. In Four Parts. Part I. A—Dov. New York: Macmillan & Co., 1879. Pp. 176. Price, $2.50.

A KNOWLEDGE of the etymology of words is of essential importance in fixing their meaning; hence a work like that named above can not fail to be useful, if only the author brings to his task the requisite scholarship and tact. We have read but a few of the titles in this dictionary; but so excellent did they appear, both in substance and in form, that we have no hesitation in warmly commending the work to our readers.

THE ANIMAL, VEGETABLE, AND MINERAL KINGDOMS. By Mrs. N. B. WALKER. New York: Wilbur & Hastings print, 1879. Pp. 18.

THE author points out the advantages to be derived from the study of natural history in public and private schools, and makes some sensible observations on the mode of interesting young pupils in such studies.

BULLETIN OF THE UNITED STATES NATIONAL MUSEUM, No. 10. CONTRIBUTIONS TO NORTH AMERICAN ICHTHYOLOGY, No. 2. The same, No. 12. CONTRIBUTIONS TO AMERICAN ICHTHYOLOGY, No. 3. Washington: Government Printing-Office, 1878.

THE first of the two volumes named above is by Dr. David S. Jordan, and consists of two parts, viz.: 1. Notes on Cottidæ, Etheostomatidæ, Percidæ, Centrarchidæ, Aphododeridæ, Dorysomatidæ, and Cyprinidæ; 2. Synopsis of the Siluridæ of the Fresh Waters of North America. In Number 12 of the "Bulletin" are published two papers, viz.: One on the distribution of the fishes in the Alleghany region of South Carolina, Georgia, and Tennessee, with descriptions of new or little known species—the joint work of Dr. Jordan and A. W. Brayton; and another, entitled "Synopsis of the Family Catastomidæ" ("Suckers"), by Dr. Jordan.

THE AMERICAN STATISTICAL REVIEW. Vol. I., No. 1. Quarterly. New York: D. Appleton & Co. Pp. 120. Price, $5 per year.

THE purpose of this publication is, says the editor, Mr. Charles S. Hill, in his "salutatory," "to enable the capitalist, the tradesman, the farmer, and the mechanic to possess a condensed work, regularly issued, giving facts and official figures that affect their immediate interests, for their convenient reference."

PUBLICATIONS RECEIVED.

The Reign of the Stoics: History, Religion, Maxims of Self-Control, Benevolence, Justice, Philosophy. By Frederick May Holland. New York: Charles P. Somerby. 1879. Pp. 248. $1.25.

Problems of Life and Mind. Third Series. By G. H. Lewes. Boston: Houghton, Osgood & Co. $2.

Color-Blindness. By B. Joy Jeffries, M. D. Boston: Houghton, Osgood & Co., 1879. Pp. 329. $2.

Spiritual Communications. By Henry Kiddle. New York: Authors' Publishing Co. 1879. Pp. 350. $1.50.

Man's Moral Nature. By R. M. Bucke, M. D. New York: Putnam's Sons. 1879. Pp. 210. $1.50.

Conversations on Art Methods. By Thomas Couture. New York: Putnam's Sons. 1879. Pp. 282. $1.25.

Sportsman's Gazetteer and General Guide. By Charles Hallock. With Maps. New York: "Forest and Stream" Publishing Co. 1879. Pp. 908. $3.

Pott's Disease. By N. M. Shaffer, M. D. New York: Putnam's Sons. 1879. Pp. 82. $1.

The Great Fur Land; or, Sketches of Life in Hudson's Bay Territory. By H. M. Robinson. With numerous Illustrations. New York: Putnam's Sons. 1879. Pp. 358. $1.75.

Money in its Relations to Trade and Industry. By Francis A. Walker. New York: Holt & Co. 1879. Pp. 339. $1.25.

Ueber die erzführenden Tieferuptionen von Zinnwald-Altenberg. Von Ed. Reyer. With 5 colored Plates. Vienna: Alfred Hölder. Pp. 60.

Hall & Benjamin's Illustrated Catalogue of Chemical and Physical Apparatus. New York: Hall & Benjamin, 191 Greenwich Street. Pp. 216.

Report of the State Board of Health of Wisconsin (1878). Madison: Attwood print. 1879. Pp. 183.

Neurological Contributions. By Drs. Hammond and Morton. Vol. I., No. 1. New York: Putnam's Sons. 1879. Pp. 104. $1.

Mémoire sur le Fer natif du Groenland et sur la Dolérite qui le renferme. Par Laurence Smith de Louisville, Kentucky. With Plates. Paris: Gauthier-Villars. 1879. Pp. 54. Rapport sur un Mémoire de M. Laurence Smith relatif, etc. Commissaires: Saint-Claire Deville, Des Cloizeaux, Daubrée. Pp. 6. *Also*, Note sur un remarquable Spécimen de Siliciure de Fer par M. J.-Laurence Smith. Pp. 4. Both from the "Comptes Rendus de l'Académie des Sciences de Paris."

The Privy System of New Orleans. New Orleans: Hanseil print. Pp. 21. 1879.

Industrial News and Inventor's Guide. Vol. I., No. 1. Monthly. New York: American Industrial Exhibit Co. 1879. Pp. 20. $2 per year.

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POPULAR MISCELLANY.

Well-Water and Typhoid Fever.—In the summer of 1878 some forty persons in Rochester, whose supply of drinking-water was derived from a certain well, were taken sick with typhoid fever and other zymotic diseases. The health officer had the well closed, so that the people had to get water from other sources. Their recovery was rapid from that moment. A request was then addressed to all the physicians in the city to report the names and residences of all persons sick with typhoid fever. About fifty cases having been reported, health inspectors were sent to the various localities, who inquired into their sanitary conditions, the distance of cesspools, sewers, and privy-vaults from the wells; also whether the patients drank well-water either at their homes or at their places of business. Samples of water were taken from the wells, and submitted for analysis to Dr. Lattimore, Professor of Chemistry in the University of Rochester. The result of the inquiries was to show that, of the whole number of cases of typhoid reported, all but two had followed from the use of well-water; the exceptional cases arose from ill-ventilated apartments in close proximity to foul water-closets. It was also ascertained that a very large number of the wells in the city were situated within an average distance of less than thirty feet from cesspools and privy-vaults, while a great many were distant from them not over ten feet! In Professor Lattimore's report occurs one passage which must be quoted *in extenso*, namely, the one in which he remarks on the significance of the presence of common salt in well-water: "I would direct your special attention to the second column" [of his table showing the amount of solid matters in the water], "which shows the number of grains of common salt per gallon of water. No single indication is of so great sanitary importance in judging of the purity or impurity, and consequently of the safety or danger, of any water. How a substance, which is in itself not only harmless, but by most persons considered indispensable as an article of diet, becomes to the sanitarian a signal of danger in well-water, will be easily rendered apparent. No mineral substance is perhaps so universally diffused as common salt. It exists in the air, hence in all rain-water; in all soils, hence in all well- or spring-water, though often in quantities too minute to be weighed upon the chemist's balance, as is the case in the Hemlock Lake water of this city. Salt being remarkably soluble, it is constantly being washed out of the soil into the streams, and ultimately carried down to its great reservoir, the ocean. We may, therefore, expect to find salt present in all ordinary well-water. What might fairly be considered as the average proportion for uncontaminated well-water in Rochester can be only estimated, but it certainly can not be large. Rivers may derive large quantities of salt from the drainage of manufacturing establishments upon their banks, but wells are not usually thus affected. Therefore, whenever, in well-water, it rises above a very few grains per gallon, it becomes certain that it comes from some other source than the soil. What is that source? A moment's reflection will convince any one that nearly all the salt used for domestic purposes escapes by the way of two channels—the water-closet and the house-drain. Therefore, we should expect, what is always found on examination to be true, that whatever sewage may or may not contain, it always contains salt."

Improved Diaphragm for the Phonograph.—Messrs. Preece and Stroh exhibited at a recent meeting of the London Royal Society a new form of diaphragm, which intensifies the loudness and removes some of the imperfections of the present disk of the phonograph. They had sought for a diaphragm which should give all the finest shades of sonorous vibrations, and, after trying many substances, a stretched membrane of thin India-rubber, rendered rigid

by a cone of paper, was found to give the best effects. Messrs. Preece and Stroh also exhibited a machine for tracing curves of the composite character which represent the sounds of speech, especially the vowel-sounds. By this machine they are able to build up curves by putting together their constituent parts, and thus to study the various theories with regard to vowel-sounds which have been put forward. Several instruments were shown by which the vowel-sounds were reproduced with more or less exactitude by vibrating a disk in accordance with the curves formed by the curve-machine. One of them makes a simple and good siren, reliable for measurements, and gives promise of introducing a new musical machine which will give sweet sounds by the mechanical vibration of a disk. Though the knowledge of vowel-sounds is far from complete, Helmholtz's theory has been fully confirmed by the work the authors have done. The sounds can not, however, be, they say, exactly reproduced by mechanical means at present. Some interesting experiments were made on the loudness of sound, tending to show, it was urged, that sufficient importance has not been attached to the quantity of air thrown into vibration. Disks of different diameter, though vibrated with the same amplitude and pitch, increase in loudness very largely with the increasing dimensions of the disk.

A Large Terrestrial Globe.—A New York artificer, Grube, has constructed what purports to be the largest globe of the earth now in existence, showing all the prominent features of its surface. Its diameter is four feet and about one inch, the scale being one to 10,000,000. The range of even the Himalayas would not be visible upon this globe if the same scale were adopted for the elevations as for the map, and accordingly the relief is made upon a scale which exaggerates heights twenty times. The oceans, seas, and rivers are colored blue; the continents are yellow; the glaciers, icebergs and floating cakes of ice, white. Plains and mountain ranges are clearly shown, and every part of the world is exhibited in its true character. Red, black, and white lines cross the globe to indicate the isothermal belts, the variations of the magnetic needle, the date line where ships correct their logs by skipping from Saturday to Monday, and *vice versa*, and other facts of like character. The map has been corrected in the light of the latest discoveries. The northern coast of Siberia has been much altered in the atlases by the Nordenskjöld Expedition, the ships sailing in deep water over places marked as 500 miles inland, and being compelled to go hundreds of miles around promontories, etc., which are occupied on the maps by bodies of water. The globe is made of wood; the relief is formed by wax. Mr. Grube has been two years in perfecting his globe.

Is the "Uniformity System" an American Idea?—Among the many mechanical geniuses who by their inventions have helped to develop the manufacturing industries of the United States, none is entitled to higher rank than Thomas Blanchard, inventor of the tack-making machine, the machine for turning gun-stocks, that for making shoe-lasts, of an improved process for bending timber, and of many other mechanical contrivances. An interesting sketch of Blanchard's life, written by Asa H. Waters, has recently been published for the purpose of vindicating for Blanchard his just place among American worthies, refused to him by certain historians of our national industries. Mr. Waters's pamphlet is a valuable contribution to the literature of invention, but he is certainly in error when he claims for Blanchard the credit of having originated what is known as the "uniformity system" in manufacture—the idea of making any number of perfectly uniform copies of the several parts of a piece of mechanism so that one copy may be interchanged with any other copy of the same part.

The origination of this idea is asserted by the author for Blanchard in the following terms: "This perfect uniformity of Blanchard's work" (with the gun-stock-turning machine) "suggested the idea of having all the parts of the guns made at the armories perfectly uniform, so as to be interchangeable" (p. 9). Again, same page:

"The War Department, impressed with the importance of having the guns so made that after a battle the broken ones could be readjusted, ordered the Springfield Armory

to make all the parts interchangeable. After two years' effort the thing was accomplished. Lettering and numbering were abolished; all the component parts, even of the lock, were got out in large numbers, and thrown together indiscriminately. Thus was inaugurated the 'uniformity system' so called. . . . It is not claimed that the whole credit of the 'uniformity system' should be given to Blanchard. . . . But to Blanchard belongs the credit of being its forerunner and suggester." And in a letter from Mr. Waters to us this system is declared to be "wholly of *American* origin," and he adds that in Europe it is known as "the American system."

Now, that the *practical execution* of the uniformity system was facilitated by Blanchard's invention is readily admitted; but the idea itself, and the execution of it, on a small scale, belong to an earlier period, and to another country. The all-sufficient proof of this is found in the following letter, written from Paris, under the date of August 30, 1785. The writer of this letter, Thomas Jefferson, addressing John Jay, says: "An improvement is made here in the construction of muskets. . . . It consists in making every part of them so exactly alike that what belongs to any one may be used for every other musket in the magazine. The Government . . . . is establishing a large manufactory for the purpose of putting it into execution. As yet the inventor has only completed the lock of the musket on this plan. He will proceed immediately to have the barrel, stock, and other parts, executed in the same way. The workman . . . . presented me the parts of fifty locks taken to pieces and arranged in compartments. I put several together myself, taking pieces at hazard as they came to hand, and they fitted in the most perfect manner." The letter will be found in the "Writings of Thomas Jefferson."

Insanity in Russia.—The ratio of insane persons to the whole population is extraordinarily high in Russia, namely, as 1 to 450. The causes of this have been investigated by Dr. Finkelburg, member of the Public Health Commission, and he has made it the subject of a lecture. Among the working classes he observes that the lack of physical and intellectual education, insufficient food, unhealthy dwellings, and a certain indolence of mind, contribute partly to the evil. But it is chiefly the abuse of alcoholic liquors that fills the lunatic asylums as well as the prisons. In the former drunkards figure to the extent of a fifth; in the prisons they constitute two fifths. With regard to educated people, the causes of their insanity are naturally very different, and they often date from the earliest education. Children do not, in general, get as much rest as they absolutely need. That a child work diligently, keep its place in class, or quickly advance in the school grades, is all that is demanded, and people do not trouble themselves in the least as to whether the young and tender brain, kept in incessant activity, may not suddenly stop in its functions or its growth. Rousseau insisted on a purely negative education till twelve years of age, and in this he was wiser than our schoolmasters. The child that has lived in the open air to this age without contracting bad habits will have greater force of apprehension and will progress more rapidly than another who has been fatigued by premature work. Among adults, Professor Finkelburg distinguishes two great classes—men of work and men of pleasure. Continual activity and the suitable exercise of all the faculties are necessary to the preservation of intellectual and physical health, for it is the idlers that furnish the greatest number of hypochondriacs. But there is the excess of the overworked man, who is liable to mental maladies arising from fatigue of mind, joined with material cares, absence of sleep, emotions and agitations caused by a goal always imagined but never reached. Professor Finkelburg concluded by urging that every man should try as much as possible to vary his occupations, whatever they be, to give his tired mind agreeable recreation, to take walks regularly in the open air, etc., in order to restore the equilibrium of functions of body and mind.

Survival of Superstitious Beliefs.—Here are a few illustrations of the persistence of superstitious beliefs. They are taken from a paper in "All the Year Round," entitled "Some Popular Cures." Many, if not all of these beliefs, doubtless survive even on

this side of the Atlantic. A cure for whooping-cough, in use not only in England but in North Germany, consists in putting into the mouth of the whooping child a newly-caught fish, and then letting it go again. The cough is communicated to the fish. Another cure for the same malady consists in passing the child nine times under and over a donkey. To charm away warts, an elder-shoot is to be rubbed over them; then as many notches are cut on the twig as there are warts. The twig is buried, and as it rots away the warts disappear. There are persons still living who have been stroked by a hanged man's hand for the sake of dispelling tumors. In Devonshire there is a superstition that, if a person suffering from any disease throw a handkerchief in the coffin of a suicide, the disease will be cured as the handkerchief rots away. In other localities, the fore-foot of a hare, worn constantly in the pocket, is considered a potent charm against rheumatism. A like practice is found in this country, a horse-chestnut taking the place of the hare's foot. In some places the anti-rheumatic talisman is a potato. Bread baked on "Good Friday" is supposed to possess wonderful curative virtues. Such bread, it seems, never grows moldy. It is often kept for years, sometimes as many as twenty. It is most effectual when taken grated in brandy. Nor is it only for man's ailments that Good Friday bread is medicine; it is also considered good for some of the complaints of animals—for instance, it cures "the scours" in calves.

Climate at Great Altitudes.—The "Little Annie gold mine," in Rio Grande County, Colorado, is doubtless the highest gold mine worked anywhere on the globe, its elevation being 11,300 feet above sea-level. An interesting account of the climatic conditions here existing is given by Professor C. E. Robins, in the "Kansas City Review of Science." The geographical position of the camp is 37° 28′ 18″ north, and longitude 106° 30′ west—that is to say, it is in the latitude of Syracuse, the most southerly city of Europe; but, owing to the elevation, the climate is arctic. The mean annual temperature in 1877–'78 was 26·95° Fahr., the maximum being 69° (July), and the minimum −24° (November). The mean maximum was 50·4°, and the mean minimum 4·58° for the twelve months. Snow fell every month except July, 1877; few nights are without frost; the fall of snow is about twenty-four feet per year. The dry atmosphere is scarcely ever *chilly*. Even when the temperature is as low as −10°, the air is generally still. From the middle of November to the middle of June locomotion is performed on snow-shoes—runners of the Norwegian pattern. Absolutely cloudless days are very common. On the 11th, 12th, and 13th of August, the sun, moon, and several stars were visible from 10 A. M. to 2 P. M. Of a lunar rainbow, seen on the evening of August 4th, the same year, Professor Robins says that "it appeared about 9 P. M., the moon being full; and it lasted fifteen minutes. The chromatic scale was complete in the primary, and the secondary arc was perfectly defined around the entire semicircle. The upper outlines of the mountains were but faintly discovered through the blackness of the storm, while the valley of the North Alamosa was flooded under the arch by an inundation of intense light, brighter than that under the most brilliant aurora, but golden." Of parhelia there are about half a dozen striking exhibitions every year. Meteors are frequent, but the author has not observed either *paraselenæ*, aurora borealis, or mirage.

The Seeds of Disease.—It is believed by Pasteur that he has discovered the germs which produce puerperal fever and malignant pustule. The primary organism which engenders puerperal fever he describes as presenting itself in the form of cells united to each other in series of two, four, or six, and each having an average diameter of two thousandths of a millimetre. Of the researches which have resulted in the demonstration of the germs of malignant pustule we take the following account from the "Medical and Surgical Reporter": "M. Pasteur's researches on malignant pustule have proved to him that the disease was produced by the presence of the bacteridium discovered in 1860 by M. Davaine, and this demonstration was made by the application of the method of culture which

M. Pasteur employed in 1857, and which enables him to obtain microscopic organisms in a state of purity—the only means of arriving at certain results. An infinitely small drop of the blood from a case of malignant pustule is taken, and it is sown in the cultivating fluid constituted by a froth of beer-yeast; a little drop of this fluid is taken again, and sown in a new medium of the same kind, and so on. Thus the media of culture may be multiplied indefinitely to a certain extent during years by the aid of a single droplet of blood taken originally from the case, and one may have always a liquid the inoculation of which in certain animals, such as the sheep or Guinea-pig, reproduces in those animals malignant pustulæ. If this fluid is filtered through a plaster filter, nothing results from the inoculation of the fluid parts which have traversed the filter, but, if the figurate elements which remain on the filter be inoculated, all conditions of the pustular disease are produced. It is the same with the cholera of fowls, and perhaps with puerperal septicæmia."

Marey on Electrical Fishes.—Of a communication from Professor Marey to the Paris Academy of Sciences on electrical fishes, a brief summary is given in the "Revue Scientifique," from which we learn that the author employed a telephone in studying the nature of the electrical discharge of the gymnotus, and the torpedo. Physiologists long ago pointed out certain analogies of innervation, chemical composition, and structure observable between muscles and the electrical apparatus of these animals. It remained to be discovered whether these analogies also exist in the functionment of the two organs. Marey's experiments go to show that the electrical and the muscular functions are in reality homologous, and that they are destined to explain each other. The author also investigated the question whether in those species of fishes which give the electrical discharge there is to be observed a multiplicity of electrical discharges just as a multiplicity of shocks are to be observed in muscular action. The experiments yielded affirmative results. They were made according to the graphic method, as also with the aid of the telephone, the latter instrument being specially adapted for this kind of investigation, inasmuch as it gives a sound when it is traversed by successive currents of sufficient frequency.

Variable Stars.—In directing attention to a certain remarkable star, the "Academy" relates an interesting passage of history connected with it. A Jesuit Professor at Ingolstadt, Christopher Scheiner, was one of the first observers of sun-spots, having noticed them in March, 1611. In accordance with the rule of his order, he communicated his discovery to Budæus, his superior, who, being a disciple of Aristotle, would not accept the observation as correct, inasmuch as no such thing was to be found mentioned in the works of "the Philosopher." When Scheiner had satisfied himself that he had made a true observation, he was permitted to publish the fact, but anonymously. Accordingly, he addressed several letters to Welser, a wealthy Augsburg patrician, and a great patron of learned men; these were printed, and copies sent to Galilei and other astronomers. In the autumn of 1612 Welser published three more letters by Scheiner, under the title "De Maculis solaribus," etc., the second of which, dated April 14, 1612, records observations of Jupiter and his satellites from March 29th to April 8th, among them some observations to which Professor Winnecke, of Strasburg, has lately drawn attention. In order to understand why observations of the satellites of Jupiter were mixed up with those of sun-spots, one must bear in mind that at that time Scheiner still assumed the spots to be merely satellites of the sun, and thus avoided inconvenient questions respecting the purity of the sun's light, which the Aristotelians would not give up. While observing Jupiter's satellites he saw something which offered, as he fancied, a new analogy in support of his opinion; for on March 30, 1612, he remarked in the field of the telescope, besides the four satellites, a fifth star, which he had not noted the previous night. This star decreased in brightness from night to night, and had, on April 9th, already passed the limit of visibility. Scheiner, moreover, thought he had remarked a small amount of motion, and he

accordingly considered the star to be a fifth satellite of Jupiter. The statements contained in his letter agree sufficiently with the assumption that the star was or is a variable fixed star, and the diagrams and descriptions indicate that the conjunction of Jupiter and of the star occurred on April 7th. By means of the geocentric place of Jupiter computed for the date, Winnecke has been enabled to identify the observed star with Lalande's 18,886, a star of the eighth or the seventh to eighth magnitude, which, during the last half century, seems to have varied little in brightness. Variable stars, in the sense of the term as now used, were unknown in Scheiner's time, and his description of the rapid decrease of the star's light carries with it some proof of its truthfulness. The spectroscopic observation of this star, with sufficiently powerful instruments, would be very desirable. Its place for 1855, date of the Bonner Durchmusterung, is right ascension 9h. 29m. 21·2s., and declination +15° 52·1′.

Identity of Heat and Light.—In a recent lecture, Mr. W. H. Preece, the English electrician, made the following interesting remarks on heat and light: "These two," he said, "are identical in character, though different in degree; and whenever solid matter has imparted to it motion of a very high intensity—in other words, when solid matter is raised to a very high temperature—it becomes luminous. The amount of light is dependent on the height of this temperature; and it is a very remarkable fact that all solid bodies become self-luminous at the same temperature. This was determined by Daniell to be 980°, by Wedgwood 947°, by Draper 977°; so that we may approximately assume the temperature at which bodies begin to show a dull light to be 1,000°. The intensity of light, however, increases in a greater ratio than the temperature. For instance, platinum at 2,600° emits 40 times more light than at 1,900°. Bodies when raised to incandescence pass through all stages of the spectrum; as the temperature increases, so does the refrangibility of the rays of light. Thus, where a body is at a temperature of 250°, it may be called warm; at 500°, hot. At 1,000°, we have the red rays; at 1,200°, the orange rays; at 1,300°, the yellow rays; at 1,500°, the blue rays; at 1,700°, the indigo rays; and at 2,000°, the violet rays. So that any body raised to a temperature above 2,000° will emit all the rays of the sun. Inversely, the spectroscope may thus be enabled to tell us the temperature of the different lights, and it is perhaps because some lights do not exceed 1,300° that we have all the rays beyond the yellow."

A Horse with a Load in his Stomach.—Dr. Albin Kohn recites in "Die Natur" the particulars of the sudden death of a horse, caused by the presence of a stony concretion in the animal's stomach. The horse was to all appearance perfectly sound and well one morning when carrying his master about his estate, when suddenly he fell dead. A veterinarian opened the carcass to ascertain the cause, and found in the abdominal cavity a stone of about eight pounds' weight, and in the wall of the stomach a hole of corresponding size. The stone was submitted to Dr. Peters, of Posen, for analysis, who first cut it into halves. Each half of the rather round stone—called by Dr. Peters "magenstein," i. e., stomach-stone—looked very much like a Chester cheese. The diameter of the cut surface was from 15 to 17½ centimetres, and concentric rings are visible in it. At the center its texture is radiate. Dr. Peters supposes the animal at some time swallowed a fragment of millstone, and that around this nucleus numerous layers were afterward deposited. Externally the stone is smooth, rather hard, and of a grayish-yellow color; its composition is: ammoniomagnesic phosphate 87½ per cent., organic matter 6½, water 1½, silicic acid 1½; other salts ⅔ per cent.

"Jumping Frenchmen."—It is a very instructive narrative which Dr. G. M. Beard publishes of the doings of the "Jumpers" of the woods of Maine and Canada. These jumpers are mostly half-breed French-Canadian lumberers who have acquired the permanent habit, which they can not control, of jumping or striking out with their hands, when commanded to do so by any one who chances to be near. The habit appears to have been acquired, in the first instance, by tickling one another in the winter camps

where they cut lumber. The men are extremely ignorant, and one of their pastimes is this practice of tickling one another. When the jumpers are excited to strike or jump, or to perform any of their automatic acts, they present the appearance of entranced persons: their faces pale, eyes fixed and glassy, and limbs trembling. One of these jumpers is a waiter, and when told suddenly to "drop it," he at once lets fall whatever he may have in his hand. Another has so susceptible a stomach that he at once throws up his meal when any one "gags" or makes the motion of vomiting in his presence. The man has grown thin, and at one time was almost starved. One man, standing on the bank of a pond with a five-dollar gold-piece in his hand, was told to "throw it," and threw the money into the water. Another was standing near a kettle of fish; being told to "jump," he leaped into the kettle. In these acts the jumpers are absolute automatons, utterly without volition or responsibility: they are to be compared to persons afflicted with St. Vitus's dance, hysteria, or epilepsy. Performances of a somewhat similar character were, last winter, witnessed in a town of Vermont during a revival of religion. Here the victims of abnormal religious excitement would roll on the floor in most absurd and undignified attitudes, whence the appellation of "the holy rollers!"

New Process for the Protection of Iron Surfaces.—A new process for protecting iron from rust has been invented by M. Dodé. It consists in coating, either by means of a bath or a brush, any objects in cast or wrought iron (freed from the damp they may contain) with a composition of borate of lead, oxide of copper, and spirits of turpentine. This application soon dries on the surface of the iron, and the objects are then passed through a furnace, which is heated from 500° to 700° Fahr., according to the thickness of the articles under treatment, so as to bring them to a cherry-red heat when passing through the center of the furnace. At this point the fusion of the metallic pigment takes place; it enters the pores of the iron, and becomes homogeneously adherent thereto, covering the objects with a dark coating, which is not liable to change under the action of the air, gases, alkaline or other vapors, nor to scale off from the surfaces to which it has been applied. When any considerable depth of "inoxidation" is desired, the object may be immersed in the composition for the time requisite to absorb a sufficient quantity of it. This process supersedes painting and varnishing, and iron objects thus heated are impervious to rust. The cost of application is about half a cent per superficial square foot.

The Mance Heliograph.—The Mance heliograph, an instrument for signaling by means of reflected solar rays, is now in use among the British forces in South Africa. The signals made by the Mance heliograph are visible, under favorable conditions of position and atmosphere, to very great distances, and have been read as far as eighty and a hundred miles. It consists of a specially prepared mirror, with mechanism for reflecting the sun's rays with absolute precision to any required spot, notwithstanding the sun's apparent motion. By pressure on a finger-key the flashes are made of short or long duration, thus adapting the instrument to the Morse code of telegraphy. A second mirror is provided to permit of signaling being carried on irrespective of the sun's position. The instrument intended for field service weighs from six to eight pounds, and is mounted on a light tripod stand. The working parts are protected from injury during transit, and the complete apparatus admits of being easily carried, as it is also efficiently worked, by one man.

Experiments in Opium-Smoking.—The Russian traveler, Dr. Miclucho Maclay, while recently on a visit to Hong-Kong, experimented on the effects upon himself of smoking opium. The experiment was made at the Chinese Club, and was under the direction of Dr. Clouth, who made the following notes: Mr. Maclay was in normal health, and had fasted eighteen hours before commencing the experiment. He had never smoked tobacco. Twenty-seven pipes, equivalent to 107 grains of the opium used by the Chinese, were smoked in two and three quarter hours at tolerably regular

intervals. The third removed the feeling of languor caused by his long fast, and his pulse rose from 72 to 80. The fourth and fifth caused slight heaviness and desire for sleep, but there was no hesitation in giving correct replies to questions, though he could not guide himself about the room. After the seventh pipe the pulse fell to 70. The twelfth pipe was followed by singing in the ears, and after the thirteenth he laughed heartily, though without any cause that he can remember. Questions asked at this time were answered only after a pause, and not always correctly. He had for some time ceased to be conscious of his actions. After the twenty-fifth pipe, questions asked in a loud tone were not answered. After the last pipe had been smoked, he remarked, "I do not hear well." Forty minutes later there was a slight return of conciousness, and he said: "I am quite bewildered. May I smoke some more? Is the man with the pipe gone already?" Fifteen minutes later he was able to go home, and then retired to bed. He woke the next morning at 3 A. M. and took a hearty meal, after his fast of thirty-three hours. During the next day he felt as if he had bees in a great hollow in his head, as well as a slight headache. The organs of locomotion were first affected, next came sight and hearing, but Mr. Maclay is positive that there were no dreams, hallucinations, or visions of any sort whatever.

Descartes on the Invention of the Telescope.—Concerning the invention of the telescope, Descartes, in 1637, wrote as follows: "This invention, as illustrious as it is useful, is, to the shame of our science, due to chance and mere experiment. About thirty years ago there lived in Alkmaer, in Holland, a certain Jacob Metius, who had never studied, though both his father and his brother were professors of mathematics. He found his greatest pleasure in making burning-glasses and mirrors; and when he was thus once in possession of a lot of glasses of different forms he happened to look at the same time through two glasses, of which the one was a little thicker in the middle than on the edge, and the other thinner in the middle. He afterward fixed them in a tube, and in that way originated a telescope, from which all the later ones have been made, for as far as I know nobody as yet has sufficiently explained what form these glasses by right ought to have. On the 17th of October, 1608, this Jacob Metius (otherwise Adriaanz) applied to the States-General of the Netherlands for a reward as the inventor of the instrument two years previously. But one of his own countrymen had anticipated him in this application, for Jan Lapprey (otherwise Hans Lippersheim) had some days before presented to the States a similar instrument. Thus, then, the first *authentic publication* on record of this great invention was made when Lapprey delivered his telescope to the States-General."

"This Jan Lapprey," says the author of a paper in "The Observatory," "was born in Wesel, and followed the trade of a spectacle-maker in Middelburg. On October 2, 1608, he solicited the States for a patent for thirty years, or an annual pension for life, for the instrument he had invented, promising them to construct such instruments only for the Government. After inviting the inventor to improve the instrument, and alter it so that they could look through it with both eyes at the same time, the States determined, on October 4th, that from every province one deputy should be chosen to try the apparatus and make terms with him concerning the price. The committee declared, on October 6th, that it found the invention useful for the conntry, and nine hundred florins were offered to Lapprey for the instrument. He had at first asked three thousand florins for three instruments of rock-crystal. He was then ordered to deliver the instruments within a certain time and the patent was promised him on condition that he kept the invention a secret. Lapprey delivered the instrument in due time. He had arranged it for both eyes, and it was found satisfactory."

A Carnivorous Goose.—In communicating to "Nature" an account of a goose which had learned to eat flesh, the Duke of Argyll remarks upon the circumstance as being extremely curious, but at the same time notes the fact that cows are largely fed on fish-offal in Scandinavia. This carnivorous goose is in the possession of Mr.

W. Pike, of the island of Achill, Ireland, and was hatched in 1877 by a tame eagle. The eagle having laid three eggs, Mr. Pike took them away, substituting for them two goose-eggs, upon which the eagle sat, and in due time hatched two goslings. One of these died, and was torn up by the eagle to feed the survivor, who, to the great surprise of its foster-parent, refused to touch it or any other flesh-meat offered by the eagle. In course of time, however, the goose learned to eat flesh, and now the eagle always calls it by a sharp bark whenever there is any fresh meat in the cage. On hearing the call the goose hastens to the cage, and greedily swallows all the flesh and offal which the eagle gives it.

The King-Vulture.—A traveler in Colombia, André, confirms from personal observation the popular belief in that country that the urubu (or black vulture) dreads the king-vulture (*Sarcoramphus papa*), and slinks away when that monarch of the Cordilleras makes his appearance. On one occasion André saw the carcass of a cow covered with urubus which were greedily devouring it. Suddenly a black point appeared in the sky overhead. One of the urubus uttered a cry, and at once all the heads were raised to observe the enemy, who was coming ever nearer and nearer. In less than a minute the urubus had fled to a respectful distance, and the king, descending like a thunderbolt into the entrails of the carcass, began his meal with avidity. This operation took up half an hour, the urubus in the mean time standing around in a wide circle. They did not return to the carcass till after the king had risen majestically into the upper air.

The Size of Lightning-Rods.—In calculating the relative sectional areas of copper and iron lightning-rods, certain important factors are commonly overlooked, and thus of necessity incorrect results are obtained. The relation usually given, that an iron rod should have four times the sectional area of the copper rod, is based on the fact that copper conducts electricity six times as well as iron, while the melting-point of iron is about fifty per cent. higher than that of copper, and 6 divided by 1·5 is equal to 4. This simple treatment, as is pointed out by R. S. Brough, in the "Philosophical Magazine," is incomplete, because it neglects these factors: 1. The influence of the rise of temperature in increasing the electrical resistance of the metal; 2. The difference between the specific heats of the copper and iron; 3. The fact that the iron rod being made several times more massive than the copper one, it will require a proportionally greater quantity of heat to increase its temperature. Taking these considerations into account, Mr. Brough finds that the sectional area of an iron rod should be to the sectional area of a copper rod in the ratio of 8 to 3.

NOTES.

THE forty-ninth meeting of the British Association for the Advancement of Science will be held at Sheffield on Wednesday, August 20, 1879, under the presidency of Professor G. J. Allman, M. D., LL. D., F. R. S., L. & E. M. R. G. A., Pres. L. S. General Secretaries, Douglas Galton, P. S. Salator; Assistant Secretary, J. E. H. Gordon.

THE American Association for the Advancement of Science will assemble this year at Saratoga Springs, New York, on August 27th. Excursions to various points are contemplated, and the meeting promises to be a successful one. Officers of the Saratoga meeting: President, George F. Barker; Vice-President, Section A, S. P. Langley; Vice-President, Section B, J. W. Powell; chairman of Chemistry Sub-Section, Ira Remsen; chairman of Microscopy Sub-Section, Edward W. Morley.

THE French Association for the Advancement of Science will meet this year at Montpellier, on August 28th. The officers of the Association are: President, M. Bardoux; Vice-President, M. Krantz; General Secretary, Count de Saporta.

WE have received, but too late for mention in our June number, a circular announcing the second session of the Chesapeake Zoölogical Laboratory of Johns Hopkins University. The Laboratory is announced to be opened about June 20th, at Crisfield, on the Eastern Shore of Chesapeake Bay. One of the barges of the Maryland Fish Commission will be fitted up as a laboratory, and another barge will be used as a dormitory. As there will be room for only

ten persons, none but those who are already acquainted with the methods of zoölogical work will be accepted as members of the party. A fee of ten dollars will be charged for the use of the laboratory outfit. Board will cost about five dollars per week.

MR. J. D. PUTNAM, Secretary of the Davenport Academy of Sciences, has presented to the editor of the "American Naturalist" photographs of two pipes found in a mound situated in Muscatine County, Iowa, one of them representing an animal like a bear, the other *an elephant*. Were the mound-builders, then, contemporary with the mammoth on this continent? In Grant County, Wisconsin, there was lately discovered an elephant-mound—that is, a mound fashioned to represent an elephant.

HEINRICH WILHELM DOVE, Professor of Physics in the University of Berlin, and distinguished for his researches in meteorology, died at Berlin, April 5th. He was born in 1803 at Liegnitz, Silesia; studied at the Universities of Breslau and Berlin, and in 1826 took the degree of Doctor at the latter university. In the same year he became Assistant Professor of Physics at Königsberg, and a few years later at Berlin, becoming full professor in 1845. He was the author of several important works on meteorology, climatology, electricity, and polarized light. A few years ago he was appointed director-general of all the observatories of Prussia. His work on "The Law of Storms" was translated into French and English.

PROFESSOR J. LAWRENCE SMITH, of Louisville, Kentucky, was elected by the Paris Academy of Sciences, on March 31st, a Corresponding Member in the room of the late Sir Charles Lyell.

THE National Academy, at its meeting in April, adopted a resolution declaring that "provision should be made by State legislation for giving instruction in the principles of the metric system in all the elementary schools of the country, and for making a knowledge of the system a requisite for admission into educational institutions of higher grade; also that laws should be enacted by Congress, enforcing the use in the domestic mail service of a metric unit of postal weight identical with that already employed in the foreign, requiring the assessment of duties upon merchandise imported under metric invoices to be made in accordance with a tariff adapted to metric denominations of weight and measure, and expressing the weights of all coins issued from the mints of the United States in grammes and milligrammes, and no longer in grains and fractions of grains, as at present."

A FRENCH traveler, Charnay, who has explored the east and west portions of the island of Java, claims to have discovered a close affinity between the remains of the civilization introduced by Hindoo Buddhists and that of ancient Mexico.

IN the best schools in Holland there is always, besides the teacher, an attendant who sees to the personal condition of each child upon daily entering the school. The object of this supervision is to promote among the children a due regard to cleanliness and tidiness, and also, as far as possible, to prevent the introduction of contagious diseases.

MR. FRANCIS GALTON advocates the use of experiments in teaching physical geography. Erosion of the earth's surface by streams, the formation of sand, gravel, and clay deposits, the formation of deltas at the mouths of rivers, and other phenomena of physical geography, or physiography, he would illustrate with the aid of a can of water and a quantity of sand, gravel, and clay. Most of the great features of physical geography, as glacial action, mountain formation, etc., might be effectually taught by like simple experiments.

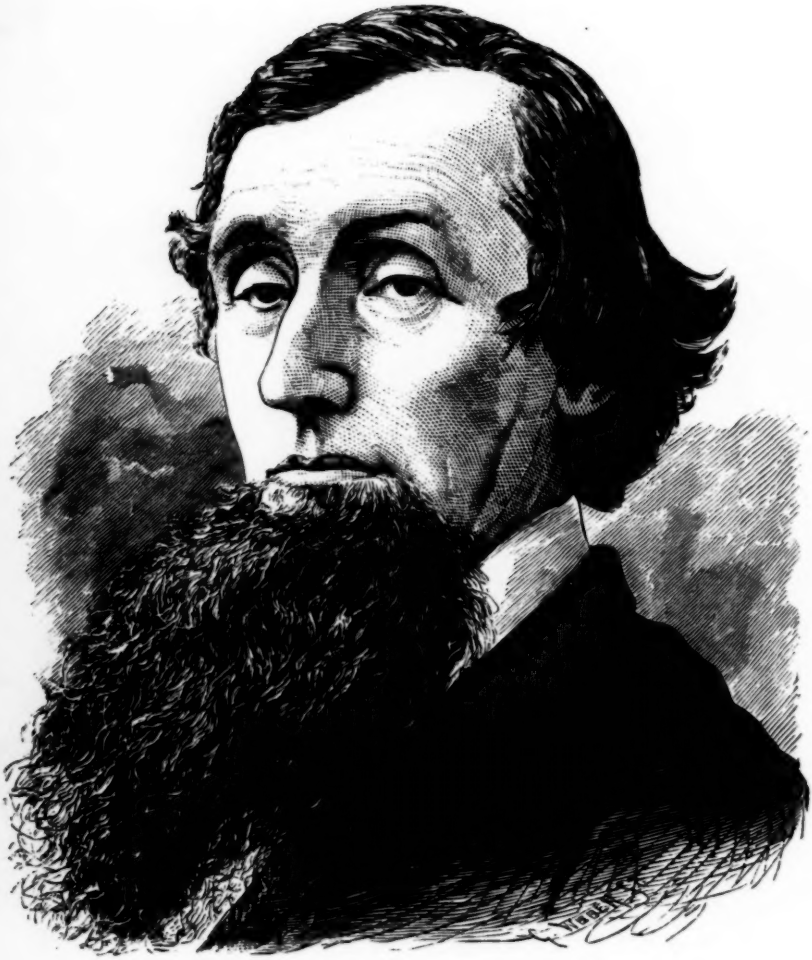
IT has been found, by Messrs. Exner and Goldschmidt, that the electrical resistance of pure water uniformly decreases as the temperature rises; at 99° centigrade it is about one-third of what it is at 20°. A similar result is observed with water acidulated with sulphuric acid.

PROFESSOR ASAPH HALL, discoverer of the satellites of Mars, was, on May 18th, chosen a Corresponding Member of the Academy of Sciences of Paris, receiving thirty-three votes in a total of forty-seven. Among his competitors were Schiapparelli, Respighi, and Warren de La Rue.

FOUR volumes of the literary and scientific remains of the late Professor W. K. Clifford are announced for early publication, viz., a volume of mathematical papers; two volumes of essays and lectures; and a small volume containing three popular lectures on "Seeing and Thinking."

IN a report made by the Department of Agriculture of the Italian Government, it is stated that borax used instead of salt in preserving butter imparts to the butter no flavor whatever, while it is entirely innocuous. Samples of fresh butter, in which much of the buttermilk was purposely left, have retained their natural fine flavor without change for three months after having been salted with borax.

M. PAUL DE SOLEILLET recently set out from St. Louis, on the Senegal, with the intention of reaching Algeria through the Sahara.



DANIEL VAUGHAN.